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This is a collection of reports of student award winning science projects that have appeared in "The Science Teacher." Grade levels 7-12 are represented with projects categorized as follows: biology, chemistry and physics, earth-space science, and miscellaneous. In each section the abstracts are arranged in order of increasing complexity beginning with seventh grade projects up to senior projects. At the end of each abstract are suggestions for further investigations. (BC)

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PROJECTS**

NATIONAL SCIENCE TEACHERS ASSOCIATION

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INTRODUCTION

One of the recurring requests that comes to us in the Student Development Programs office at NSTA is "Please send me some new ideas for science projects." It is phrased in various ways; it may come from teacher or from student, but any way you translate it, it asks for help.

It seemed appropriate to respond to that call for help by collecting a group of the carefully edited reports of student award-winning science projects that have appeared in *The Science Teacher* from time to time. This book is also published as a particular service for the many members and sponsors of the Future Scientists of America Clubs chartered by the National Science Teachers Association.

You will find included accounts of science projects chosen from a variety of disciplines, and from all grade levels (7-12). These first appeared in issues of *The Science Teacher* from October 1963 through January 1967, selected and edited by Victor M. Showalter and Irwin L. Slesnick.

The reports are arranged in four sections according to subject matter: biology, chemistry and physics, earth-space science, and miscellaneous. In each of these sections the abstracts are arranged in order of increasing complexity beginning with those of seventh graders and going up through the seniors' projects. At the end of each short report will be found the editors' suggestions for further investigations: hundreds of new project ideas stemming from the ones reported.

The students' reports were entries in NSTA's Future Scientists of America Awards Program. The ones selected for publication were all Regional Winning Projects. The Ford Motor Company supported this awards program during the time these entries appeared.

The Future Scientists of America Awards Program is one of the student programs offered by NSTA as one of its services to science education. Other NSTA student programs are the following:

The NASA-NSTA Youth Science Congress Program
The International Youth Science Fortnight and European Tour

Publications for Science Students

The Future Scientists of America Club Program

The FSA Clubs are organized to give interested students an opportunity to meet together and benefit from the common sharing of the scientific interests and abilities of their fellow club members. An FSA club is a scientific community in miniature. Though nationally organized and identified, each club is free to develop a program most suited to its own needs. NSTA stands ready at all times to furnish guidance for a new club or new sponsor, and to provide suggestions for clubs that wish to try a change of program.

Specific services furnished to all new clubs are a charter plaque with the club name on it, suitable for wall display, and a copy of the *FSA Sponsor's Guidebook*. The *Guidebook*, which was completely revised and brought up-to-date in 1967, offers suggestions on how to organize a new club, how to plan and conduct meetings, how to begin research work, how to prepare and present science papers, and many other things a club sponsor will find helpful.

Each year, all clubs receive free membership cards, copies of the club newsletter *Centrifuge*, published quarterly, and other selected mailings. Attractive pins, charms, and shoulder patches are available at moderate cost. A science club may affiliate as a chapter of FSA for an initial fee of \$6, and may renew its membership each year for a fee of only \$3.

This book has been made possible by the devoted work of the editors over a period of years. Both of them have had long experience in teaching. Dr. Showalter is now Research Associate with the Educational Research Council, Cleveland, Ohio. Mr. Slesnick is presently serving as Science Education Advisor to the Agency for International Development, New Delhi, India.

DOROTHY K. CULBERT

Director, Student Development Programs

BIOLOGY

Propagation of African Violets

DONNA BEHRENS

Seventh Grade, Ottawa Hills High School, Grand Rapids, Michigan. Teacher, Judson M. VanderWal. Winner, Silver Plaque Award, Region VII

In this project, Donna attempted to demonstrate several methods of plant propagation, processes by which plants can be increased in number. Though there are many ways of propagating plants, each method can be placed in one of two groups—sexual processes or asexual processes.

A sexual process involves the flower, pollination, fertilization, and appearance of a seed (or seeds) in a fruit. An asexual process involves some plant part, other than a seed, which grows into a mature plant. Leaf cuttings from African violets were placed in water and damp vermiculite in this project's successful demonstration of asexual propagation.

Donna also attempted a type of asexual reproduction called "air layering" but met with no success. (A high school student with more laboratory experience might find investigation of this process worth while.) Among the outcomes of the project was the realization that there are "... many different conditions that can affect the progress ... of any plant."

Specific questions that could serve as the basis for further studies of African violet propagation by leaf cuttings are:

1. Does propagation by means of leaf cutting proceed best when the wet ends of the leaf stems are totally submerged in water or when they are placed in damp sand or vermiculite? If there is a difference, is it due to the material in contact with the stems or to the light (or absence of it) that reaches the cutting?
2. Does polarized light (or colored light) affect propagation by using leaf cuttings? (Most people say African violets do best when placed in a north window.)
3. Do vibration, electric current, or

other types of energy affect propagation?

4. What pH is best for propagation?

The Panic Speed of White Mice

STACEY WONG

Seventh Grade, Maryknoll Grade School, Honolulu, Hawaii. Teacher, Sister Lourdes Marie Tóomey. Winner, Silver Plaque Award, Region XI

This investigation was started when Stacey observed that white mice in a pet shop cage ran away from the proprietor's hand when he attempted to catch one. This phenomenon prompted Stacey to wonder just how fast mice could run when frightened.

To answer the question an original piece of apparatus was built. It consisted of a model train track laid out in a circle of 10 feet circumference and closely enclosed by an aluminum "fence" on each side of the track. In use, a mouse was placed in front of the locomotive; and, as the locomotive moved, the mouse was motivated to run in front of it. There is no report that the mouse was ever affected by the voltage across the rails. Apparently the oncoming locomotive itself was sufficient to induce panic.

Using this apparatus and a stopwatch, the average "panic speed" for white mice was found to be 1.8 feet per second with extremes of 1.6 and 2.0 feet per second.

The top speed of running, flying, or swimming animals has always evoked much interest and controversy. Consider the following situations for further study:

1. Does 1.8 feet per second represent the real top speed of mice? Could other motivating devices induce greater speed?
2. Can mice be trained to increase their top speed? Can diet influence top speed? Can mice run faster in pure oxygen than in air? (Since humans are also mammals, track

coaches might be interested in the results.)

3. Top speed for humans ranges from 30 feet per second (hundred yard dash) to 22 feet per second (mile run). Considering relative size, which is the better runner, man or mouse? A good reference for this question is J. B. S. Haldane's "On Being the Right Size," which is in *New World of Mathematics*, Volume 2. Simon and Schuster. 1956.
4. What are the absolute top speeds of other animals? Can trout swim faster than bluegills? Someone has suggested that honeybees always fly at the same speed when returning to the hive—is this statement valid?
5. This reviewer has observed a hamster in a cage equipped with an activity wheel and counter and found that the animal ran 8 miles in one 12-hour period. Why do these animals run so much?

The Effect of Egg Whites and Tears on Bacteria

MARGARET WINCHELL

Seventh Grade, Charles Sumner Smith High School, Lincoln, Massachusetts. Teacher, Neil Jorgensen. Winner, Silver Plaque Award, Region I

Do human tears contain an antibiotic? Sir Alexander Fleming discovered that human tears added to a bacteria culture in broth produced a clearing of the culture. The clearing was interpreted as being caused by a disintegration (lysis) of the bacterial cells. Fleming called the active agent in tears "lysozyme." Further experiments showed that the same, or a similar, substance may be even more concentrated in egg whites.

In this study Fleming's findings were rechecked as the investigator compared the relative effectiveness of the lysozymes in tears and in egg whites. Not the least of the experimenter's problems was that of collecting human tears. She solved the problem by squeezing a

lemon peel over an eye (her own?) and as tears formed they were collected in a pipette. The tears were absorbed on small disks of sterile filter paper. Similar disks were used to absorb egg whites. Other disks were impregnated with diluted (1:1, 1:2, 1:3) tears and egg whites. Control disks were impregnated with distilled water.

Standard agar cultures in petri dishes were "inoculated" with bacteria, and the paper disks containing tears and egg whites were placed on the surface of the medium. After incubation for two days the "zones of inhibition" around each disk were measured. Generally, tears produced the greatest inhibition.

A second experiment involved an inoculated "thioglycelate" medium that was incubated overnight. Drops of tears and egg white were added to different cloudy cultures. Over a period of three hours, clearing occurred. The first changes were noticeable within the first five minutes. At this point the investigation, as reported, could have been improved by making quantitative observations of clearing rates (see the following).

The principal conclusion was, "The lysozyme in tears is shown to be a more effective inhibitor of certain bacteria than the lysozyme in egg whites."

The report of the study concluded with further questions for investigation. Consider the following:

1. Are chemically induced (lemon juice) tears the same as those induced emotionally?
2. Does the age of the egg white or of the person producing the tears have any effect on their lysogenic properties?
3. Do other plant and animal fluids show evidence of containing lysozymes?
4. It is generally agreed that if a reaction is physical, raising the temperature of the reaction 10°C will double its rate. If the reaction is chemical, the reaction rate will be more than doubled by the same temperature increase. On the basis of this, is lysozyme action chemical or physical?

The Effect of Thyroid Suspension on Growth and Regeneration of Planaria

NEIL STAHL

Eighth Grade, Junior High School No. 109, New York, New York. Teacher, Julian Heyman.

Winner, FSA Regional Award of \$25 Savings Bond, Region III

The secretions of the thyroid gland include the active hormone thyroxine ($C_{15}H_{11}I_4NO_4$). Thyroxine functions in organisms as a controller of metabolism. An effect of thyroxine excess is a speeding-up of cellular respiration accompanied by generally increased activity and the acceleration of developmental processes. Thyroxine is an amino acid, not a protein, and is not, therefore, digested when taken orally. It is inexpensive and readily obtainable.

Neil discovered through controlled tests that thyroid suspension affected the growth of planaria. He found that sizes of worms living in a state of thyroid suspension were reduced. He further discovered that the regenerating planaria literally "burned up" in response to the amount of hormone he administered.

The effect of the thyroid gland on the metamorphosis of an amphibian may suggest several problems for other investigations:

1. At what age and to what dosage do tadpoles respond best to thyroxine induced metamorphosis?
2. Are amphibians that are forced to metamorphose quickly affected in terms of structure, life expectancy, behavior?
3. To what extent is iodine a limiting factor in the metamorphosis of amphibians?
4. Does removal of thyroid glands in tadpoles result in giant tadpoles that fail to metamorphose?

The Effect of a Magnetic Field on Snails

KENNETH PETERS

Eighth Grade, Santa Barbara Junior High School, Santa Barbara, California. Teacher, Mrs. McAllister
Winner, Silver Plaque Award, Region XII

For more than one hundred years man has wondered whether organisms are affected by magnetic fields. In an early experiment, Michael Faraday placed his head between the poles of a large horseshoe magnet. (He reported

"seeing" flashes of light.) Since then some investigators have suggested that the direction-finding abilities of homing pigeons are based on the earth's magnetic field. (Tested by tying small magnets on the pigeons' heads.)

The experimenter reporting this study used snails as a representative organism. Snails are ideal because of their small size, slow rate of movement, and ease of maintenance.

Though this investigator felt his data showed "... that a magnetic field influences the movements of land snails," in sea snails, "... the experiment showed no response." His experimental techniques included placing 9 "sea snails" in a north-south orientation and then noting the direction of their orientation 20 minutes later. The same procedure was repeated in the vicinity of a "large magnet." In both cases the results were inconclusive.

Frequently students become discouraged when hoped-for clear-cut results are not obtained from experimentation. Teachers advising such a study are faced with the problem of choosing between two alternatives: (1) make sure the student draws conclusions based solely on data he has and terminate the study, or (2) encourage the student to refine the techniques and apparatus used and obtain more data. There is no sure formula to make the decision, and intuition must be relied upon.

If the advising teacher for this investigation felt that further work should be encouraged, it might have been along the following lines:

1. Obtain a much larger magnetic field.
2. Make sure that all other variables are held constant and test "with a magnetic field" and "without a magnetic field."
3. Modify procedures so that snails are started "across" the magnetic field and "along" the magnetic field and compare each to a control.
4. Repeat the trials over a long period of time so that organisms will become "accustomed" to the test situation.

It should be noted here that an excellent team research study would involve a whole class charged with the same problem—"Do magnetic fields affect organisms?" and let each individual or small group devise its own experiment.

Conditioned Reflex in Earthworms

SANDRA VINEYARD

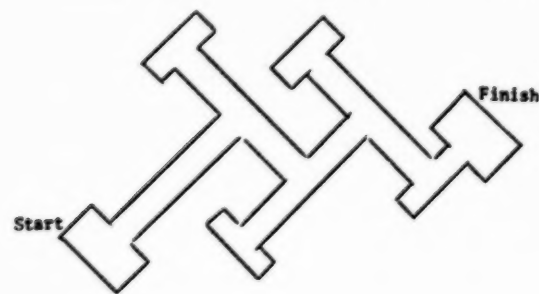
Eighth Grade, Miami Springs Junior High School, Miami Springs, Florida. Teacher, Mr. T. F. Ryan. Winner, Silver Plaque Award, Region VI

Animals, from the simplest to the most complex, modify their behavior by previous experience. This adaptation is called learning. We humans place a high premium on learning. Indeed, civilization is sustained and advanced by learning, and a large segment of society is fully engaged in directing the learning of others. Yet, learning as a phenomenon is one of the most exciting frontiers in science. One research avenue involves simple animals, such as protozoans and various phyla of worms, popularly thought to be incapable of learning.

Sandra Vineyard inquired about the ability of earthworms to change their left-right turning behavior in a "T" maze such as the one sketched here. She collected two populations of earthworms, one short and presumably young, the other long and presumably old. In pretests the shorter worm population indicated individually strong preferences for turning either left or right. Turning among the longer worms appeared to be random. Sandra next successfully taught worms to turn either left or right using an electrical shock as the primary stimulus.

What can Sandra do next? Consider the following questions:

1. Can a worm associate a preceding secondary stimulus, such as a bright light or a loud noise, with the primary stimulus (electrical shock)?



2. Can worms be taught multiple sequences of turns in simple "T" mazes of two units and three choice points, as illustrated in the figure?
3. What differences in learning behavior can be detected as one compares young worms with old worms?

4. Is the supraesophageal ganglion or "brain" of worms the center for learning left-right turning by the electrical shock method?
5. How good is a worm's memory?
6. How many correct turns out of how many trials are necessary for the worm to "pass the course," thus demonstrating that he has learned?

The Effect of Magnetism on Yeast Cells

RICHARD JUNG

Eighth Grade, Freeburg Elementary High School, Freeburg, Illinois. Teacher, Arthur Miller. Winner, Silver Plaque Award, Region VIII

Richard Jung read "Magnetic Fields and Life" in the November 7, 1962, issue of *Science World*. This article discussed research on biomagnetic phenomena. One of the studies described concerned the reaction of growing yeast exposed in magnetic fields. Yeast cells grown on malt agar surfaces showed a reduction in budding the closer they were to the center of the field of a horseshoe magnet. The research on yeast was done prior to 1938 by Dr. Grace Kimball. In discussing her research with a writer for *Science World*, Dr. Kimball recalled that she had encountered difficulty obtaining consistent results.

Richard was inspired to repeat Dr. Kimball's experiment. Although he did not obtain a copy of her original paper to study, he did get enough information about techniques and procedures from the *Science World* article to confirm, to his satisfaction, the results she obtained.

Richard began to inquire about the relationship of magnetism to physical and chemical reaction within plants and animals. He read studies claiming that when young mice were placed in strong magnetic fields, growth stopped: Later, male mice died while females remained healthy despite the cessation of growth. Recently, several investigators found that fruit flies, maintained in bottles and attached to the poles of a horseshoe magnet, reacted differently to changes in atmospheric pressure and solar activity. Such biomagnetic phenomena penetrate a new field for research. As claims of discovery are made, other investigators are obligated to repeat experiments in order to sup-

port or contest reported results. Students should learn to recognize that repeating the experiments of others is not only a respectable occupation, but an endeavor essential to the growth of scientific knowledge.

Photoreversal of Ultraviolet Light

RAE LYN CONRAD

Ninth Grade, Fred W. Traner Junior High School, Reno, Nevada. Teacher, Patrick J. Morris.

Winner, Silver Plaque Award, Region XI

This study is an extension of previous research that has been reported in various journals. The previous work showed that "light (3000-5000A) can repair some of the ultraviolet radiation damage on the fungus *Streptomyces griseus*."

The investigator hypothesized that similar effects might be observed for other organisms. *Paramecium caudatum* was used as the experimental organism. Irradiation was done in shallow dishes using ultraviolet radiation of 2460A. Radiation time varied from 5 to 65 minutes. Treatment following radiation included: (a) "visible light," (b) "sunlight," and (c) "darkness."

Variation of exposure time showed that "a maximum of 20 minutes irradiation was possible before self-recovery was impossible in the darkness."

One unusual finding was that concurrent exposure to ultraviolet and sunlight caused "immobilization to take 20 minutes longer but did not prevent eventual death."

The fact that photoreversal *per se* was not found is probably not too surprising since paramecia and fungi are different life forms. As is the case in many research studies, unexplained phenomena are discovered during the course of the study. The delaying effect of sunlight when concurrent with ultraviolet presents a situation for hypotheses and further study.

It would be interesting to know how other simple life forms respond to ultraviolet and sunlight. In this study, the temperature was always 72°F. Variation of the temperature and replication of the experiment might provide further insights.

Growing Algae in Various Bands of the Visible Light Spectrum

LAURIE LEWIS

Ninth Grade, Indian Hills Junior High School, Shawnee Mission, Kansas. Teacher, Guy B. Kerns.

Winner, Silver Plaque Award, Region XI

Many experiments have been done with plants and the effects produced on them by colors of light. General growth and flowering have been shown to be affected. This study attempts to assess parallel effects on blue-green algae.

The conditions for experimentation were based on several assumptions. First, the algae culture containers were on the same table close to each other, thereby leading to the assumption that all were at the same temperature. A single light source was used for all cultures. Colored cellophane filters limited the light reaching each culture, and it was assumed that each dish received an equal intensity of light. (Red, yellow, blue, and colorless cellophane were used.) Another assumption was that qualitative observations were sufficient to lead to generalizations.

The investigator found that "the algae grown under red and that grown under yellow light were clumped and more plentiful than were the others." Also, "under white cellophane the algae were light green . . . and more oxygen bubbles came to the top than in the others."

Departures for further investigation could occur in testing the above assumptions or in asking and seeking answers to questions such as:

1. Why does white light cause greater evolution of oxygen (if in fact, the gas is oxygen)?
2. Does blue light inhibit algae growth, or does red light promote it?
3. Since filters absorb some light, the experiment was done with a control that had higher light intensity than had the experimental cultures. What would happen if the white light were the same intensity as the red light? How can the intensity of light of different colors be compared since the eye

is not equally sensitive to all wavelengths?

Algae are convenient organisms with which to work, and students seem intrigued with recent proposals to use algae as food. A good reference to have on hand is "Growing Fresh-water Algae in the Laboratory", Turtox Leaflet No. 5, available from General Biological Supply House, Chicago, Illinois. Single copies are free to teachers.

Is Your Cat a Southpaw?

LORRAINE HEARTEL

Ninth Grade, Watchung Hills Regional High School, Plainfield, New Jersey. Teacher, Robert F. Breuche.

Winner, Silver Plaque Award, Region IV

Problems associated with "handedness" seem to be universal since they range from the spin of subatomic particles to the frustrations encountered by left-handed children in learning to read and write. In this project, Lorraine replicated a study reported in *Science News Letter* that concluded that most cats are left-handed.

Lorraine studied 15 cats and found that all but three were left-handed (two others seemed to be nearly ambidextrous). The test used to identify handedness required the cat to reach into a cylinder to obtain a bit of meat. The test is simple, its results can be recorded clearly, and it can be repeated readily; therefore it provides an excellent basis for a research project.

In addition to the generalizations about cats' handedness, Lorraine found some evidence to suggest that perhaps this characteristic is inherited. As a hypothesis, it requires further experimentation that could utilize the same basic test used above.

Physiological-psychological phenomena are often overlooked as a source of ideas for student research projects.

One can proceed to evaluate these theories through investigations that seek answers to the following questions:

1. Can a cat be taught to be right-handed?
2. Does the handedness of cats vary from one breed to another? (The cats in Lorraine's study were of mixed or unknown ancestry.)
3. Do other mammals such as mice, dogs, and rats show handedness?

4. Do other living organisms show a directional or side preference even though they do not have paws or legs?
5. Since most humans are right-handed, does the right hand show faster reflexes than does the left?

Age Dating of Fish Utilizing the Eye Lens

MARK NEIS

Ninth Grade, Roosevelt Junior High School, Topeka, Kansas. Teacher, John Rutherford.

Winner, Silver Plaque, Region XI.

This investigation represents a logical extension of the work reported in 1959 by Rexford Lord of the Illinois Department of Conservation. He found that the dry weight of mammalian eye lens tissue continues to increase throughout the mammal's life. Finding the dry weight of an eye lens then becomes an accurate determination of the individual's age provided that standard age-lens weight curves have been established for that species.

This investigation attempted to produce just such an age-lens weight relationship for fish of three species, though here we shall consider only the data for one of those, the common crappie (*Pomoxis annularis*).

The data reported are for 15 individuals of this species caught during the month of May. The age of each fish was determined by the rather common method of counting annual rings on selected scales. Using January 1 as an arbitrary zero age, each fish was assigned an age in months.

Each specimen was sacrificed and (apparently) one eye lens was dissected. Each lens was then ". . . placed in formaldehyde for about four months to dry and then the weight and diameter of each was found." The table summarizes the data obtained by this method.

The investigator concluded, "It would seem that there was a direct relationship between the lens measurements and the age by the scale-reading method." He goes on to identify the obvious limitations imposed on the conclusion by the data.

In replicating this experiment another investigator would conceivably give attention to increasing the accuracy and age range of the data. Fish hatcheries might be able to provide large numbers of fish of known age. Both eye lenses from each fish could be used to check the accuracy of the overall method. A scientific collector's permit from the state department of conservation would allow the investigator to use nets to collect samples of game fish. A drying oven could be used instead of formaldehyde. (Lord's original work was done with an oven.)

Extensions of this investigation could be based on questions such as:

1. Is the scale method for determining age of fish valid for those individuals that live in aquaria in which food and temperature conditions are always the same (or nearly so)?
2. How does the body weight (or length) to age ratio of a given species vary from one pond to another?
3. Do all fish of a given species have the same total number of scales?

Age, size of lens, and length of body of 15 fish of species *Pomoxis annularis*

Age from Scale ^a	Diameter of Lens	Weight of Lens	Length of Specimen
month	millimeters	grams	centimeters
18	40	.050	14
18	37	.043	25
18	35	.040	23
18	36	.042	25
18	40	.043	25
18	36	.032	21
18	35	.032	22
29	45	.070	30
29	47	.077	28
29	45	.067	29
29	48	.081	29
29	47	.076	28
29	45	.073	27
30	48	.074	30
30	48	.071	29

^a Using January 1 as zero months.

Tropistic Variation in Paramecium

CHARLES LONGFELLOW

Ninth Grade, Towsontown Junior High School, Towson, Maryland. Teacher, Benjamin Poscover.

Winner, Silver Plaque Award, Region V

The title of this study suggests that some clarification needs to be made between the concepts of *tropism* and

taxis. The concept of *tropism* is usually restricted to orientation phenomena related to organisms that cannot move from one place to another (i.e., most plants). On the other hand, the concept of *taxis* implies movement of the organism from one place to another in addition to being oriented by a stimulus.

This study then deals with various *taxes* of paramecia. Phototaxis was investigated by directing light of different colors down tubes in which paramecia had been stocked. Samples were taken from the top, middle, and bottom of the tube, and the paramecia in each sample were counted. Since a 100-power microscope would probably be best, it would be useful to mix one drop of sample with an equal volume of methyl cellulose gel to slow the paramecia and facilitate counting. In repeating this study, it might be best to count the number of paramecia per field of the microscope.

In this study paramecia seemed to be positively phototactic in yellow light but negatively phototactic in red, blue, and green light. In white light, no clear results were obtained.

Chemotaxis was explored, but the methods were not sufficiently accurate to warrant any conclusions. The main difficulty here is to maintain a separation or smooth concentration gradient between ordinary water and that which contains the dissolved chemicals. If someone could invent a reliable method of doing this, he would have the beginnings of an outstanding investigation.

In observing paramecia with a microscope, it is often noted that they tend to cluster around the edge of the cover slip. What hypothetical explanation could be made? How could the hypothesis be tested?

Other investigations have reported an electrotaxis in paramecia. When two wire electrodes, attached to a source of low direct current voltages, are dipped into opposite sides of a water drop containing paramecia, their behavior is changed. Is there a minimum voltage at which this effect occurs? Is the magnitude of the effect directly proportional to the voltage? What happens when alternating current is used?

Euglena and rotifers, often found in the same "wild" cultures as paramecia offer other convenient organisms for parallel studies. Euglena are specially good for study since they usually move more slowly than do paramecia.

The Effect of an Electric Field on the Growth of Seedlings

LOIS STEIN

Tenth Grade, Jamaica High School, Jamaica, New York. Teacher, Mrs. Smith.

Winner, Silver Plaque Award, Region III

This study had two parts. One investigated the effect of an electric field on germination of a mixture of grass seeds. The other investigated the effects of an electric field on the roots of a bean seedling.

In the germination experiments grass seed mixture "was uniformly spread" on the surfaces of four soil-filled cans. The surfaces were covered with "a thin layer of soil" and the four cans (A, B, C, D) arranged as seen from above in the diagram in Figure 1.

Can A was the control, can B had two 1½ x 3-inch electrodes spaced 3 inches apart and maintained at a potential difference of 10 volts DC. Cans C and D had similar electrodes and spaces, but the voltages were 50 and 100, respectively. The seeds were "kept moist and observed twice daily."

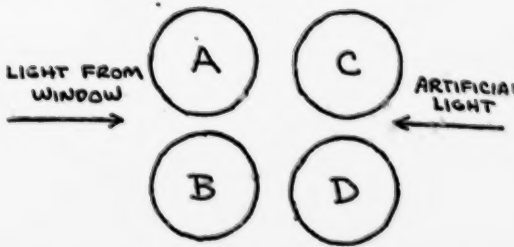


FIGURE 1. Arrangement of soil-filled, seeded cans for germination experiment.

"The first seedlings appeared in cans A and B." (Could anyone infer from this that higher voltages suppressed germination?) After four days, 15 seedlings had appeared in B, but they were not evenly distributed. *None appeared directly between the electrodes.* (What inferences can be made with this additional observation?)

After eight days, can A had 210 seedlings, can B had 110 seedlings, can C had 42 seedlings, and can D had 12 seedlings. On the basis of this, what might be predicted if alternating current had been used instead of direct current? What if 200 volts DC had been used?

In addition to the germination data, it was observed that "A dark area formed between the electrodes close to the cathode." What might be the cause of this?

In the second phase of this investigation, the experimenter germinated beans between moist blotting paper and the sides of a glass beaker. The bean seeds were placed midway between copper electrodes which were on opposite sides of the beaker. Figure 2 shows the arrangement.

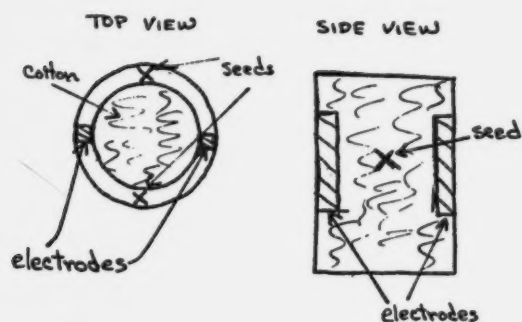


FIGURE 2. Placement of seeds and electrodes for root-growth study.

After germination and a short period of growth, roots were examined microscopically and it was concluded that "The physiological effects of electric fields are primarily the retardation of root hairs both in number and size."

For further work, it is suggested that the same experiment be repeated and that various seeds be tried. Strict control of light intensities and temperatures must be maintained.

Research and Prevention of Plant Cancer

CAROLE J. BEAUCHAMP

Tenth Grade, Chelmsford High School, Chelmsford, Massachusetts. Teacher, Mr. George Simonian.

Winner, Silver Plaque Award, Region I

Tumors, malignant and nonmalignant, occur in plants as well as in animals. One example of cancer among many species of plants is the crown gall tumor. The disease is induced by the crown gall bacterium, *Agrobacterium tumefaciens*. When a plant is inoculated with this organism, large irregular masses of undifferentiated cells may form at the site. Soon secondary tumors form at other locations in the plant. The secondary tumors are bacteria-free.

Carole attempted to discover a control for the crown gall condition in sunflower seedlings. She hoped to prevent the formation of secondary tumors by preventing the formation of a primary tumor. She accomplished this task by treating cultures of the bacterium with various antibiotics prior to

inoculation. Each antibiotic prevented tumor formation. Carole now wonders whether infected soil can be effectively treated with an antibiotic where the value of the crop warrants the expense.

Tumor tissues such as those induced by the crown gall bacterium resemble a tissue called callus. Callus can be induced by treating the end of the stem of a decapitated plant, such as the sunflower, with a concentration of indoleacetic acid. Structural and physiological comparisons of the callus and crown gall tumor tissues can lead to fascinating research studies. Carole, for example, expressed a curiosity about the nature of the "tumor-inducing principle," the agent that spreads the cancer. Callus does not have the ability to induce new callus at a distance. What difference(s) between the two kinds of abnormal growth account(s) for the spreading of the crown gall tumorous condition?

The Effects of Various Chemicals on the Rates of Regeneration in Hydra

DENNIS MULKEY

Tenth Grade, Ventura Senior High School, Ventura, California, Teacher, Carl Schorsch.

Winner, Silver Plaque Award, Region XII

The rates of self-restoration of cells, tissues, and organs are highly variable within individual organisms and among kinds of organisms. Within man regeneration occurs continuously and rapidly in the skin and in the lining of the alimentary canal. Regeneration takes place very slowly, or not at all, when nerve tissue is damaged. Regeneration of limbs is unheard of in humans. Among organisms that represent a more primitive form of life, regenerative powers include the rapid regrowth of the entire organism from a mere fragment.

Dennis Mulkey has been investigating the effects of certain salts and organic compounds upon the rate and degree of regeneration in hydra that have been cut in half transversely. After two experiments in which halves of hydra were exposed to chemical baths, Dennis observed that the rates at which head and tentacles formed on basal portions could be made to vary. He found, for example, that head and tentacles appeared on bases 40 to 50 hours after decapitation when bases

were first bathed in potassium oxalate. Basal halves that were not chemically treated regenerated to the same condition in 70 to 80 hours. Students of regeneration have become involved in investigations of other phenomena.

Listed below are some of these phenomena:

1. Altering the oxygen concentration at a regenerating surface affects rate and structure of growth.
2. Individual cells of a sponge that were separated by passage of the sponge through a fine cloth will reassemble into aggregates. These aggregates will develop into new sponges.
3. Exposure to ionizing radiation in appropriate sublethal doses results in the loss of regenerative powers of planaria.
4. In crayfish, the loss of an eye or mouth part may result in replacement by antenna and leg respectively.
5. Leg regenerative capacity is higher for spiders, insect larvae and pupae, salamanders, and tadpoles than it is for adult insects, frogs, toads, and reptiles.
6. Some regeneration of frog legs can be stimulated by preventing the formation of scar tissue over the stump or, more effectively, by greatly increasing the nerve supply to the appendage.
7. Under tissue-culture conditions, a carrot plant can be initiated from a single somatic cell.

Chromogenic Mutations

LINDA THORNTON

Tenth Grade, William Howard Taft High School, Chicago, Illinois. Teacher, Mr. Donald C. Giersch.

Winner, Silver Plaque Award, Region VIII

The purpose of this project was to study the effects of ultraviolet (UV) light on the genetics of simple plants. Specifically, Linda sought to compare the mutagenic action of UV on three species, a bacterium, a yeast, and an alga. Cultures of each organism were given various sublethal doses of UV at 2600 angstroms. Mutations were produced. Linda chose to work with those that resulted in pigment changes. These were selected because such changes are easily observed with the naked eye and

can be readily checked for true mutation.

To establish whether the chromogenic mutations were true or temporary, suspected mutants were transferred to fresh media. True mutants retained their new pigmentation in successive generations. Approximately 35 percent of the color changes were found to be temporary.

The action of UV as a mutagen is not fully understood. One theory suggests that induced mutations may be caused by the UV-stimulated production of unstable compounds such as hydrogen peroxide or organic peroxides. The idea is supported by the observation that UV-irradiated media are mutagenic to certain organisms. On the other hand, the fact that the most effective wavelength of UV for mutagenesis is the same wavelength that is absorbed maximally by DNA supports the so-called target or direct-hit theory.

Gene and chromosome mutations can be induced through the use of various agents. These include ionizing radiations such as X, alpha, beta, and gamma rays. Many chemicals have also been found to produce mutants. Colchicine applied to plants inhibits cell division while chromosome division proceeds, resulting in a mutant condition called polyploidy. Common household substances such as boric acid, ammonia, and phenol along with some 30 other chemicals have been found to be mutagenic in *Escherichia coli*.

The student whose research leads him into the search for mutagenic agents and their properties can easily become lost among the trees. In this project the forest was the search for an explanation of the physico-chemical process that is mutation. Linda was well aware of this "Big Idea." Many student project reports reveal that students are frequently unaware of the relation of their specialized study to the general scheme of things.

The Protein Content of Two Different Fungi Grown with Different Food Sources

CLYDE CROUCH

Tenth Grade, Shaker Heights High School, Shaker Heights, Ohio.
Teacher, Jack D. Miller.
Winner, Silver Plaque Award, Region VII

The green alga, *Chlorella*, has come to be regarded by some as the panacea for present and future world food shortages. Indeed, the nutritional value of *Chlorella* is impressive. This microscopic, freshwater plant is rich in proteins, carbohydrates, fats, minerals, and all vitamins except C. The culture of *Chlorella* is being studied by research groups throughout the world. However, many students of the world food problem claim that the critical nutrient shortage is, and will be, primarily protein. *Chlorella* is not the best source of protein. Currently, herbivorous animals are our main source of protein. But these animals convert carbohydrates to edible protein inefficiently. Fungi, on the other hand, are known to produce more available protein per unit of carbohydrate than do animals. Some researchers today are seeking the most efficient protein-converting fungi.

Clyde Crouch's study compared the amount of protein produced by two species of fungi, *Candida lypolytica* and *Cladosporum resinea*. Each fungus was grown in 14 media, each distinguished by a single food source. The results of the study showed that the simple protein, gelatin, was the best food source for both fungi in terms of protein produced. Of the other 13 food sources, however, it seemed that, in general, what was a good food source for one species was a poor protein producer for the other species of fungi. For example, dextrose was an excellent protein producer for *Cladosporum resinea*, but not for *Candida lypolytica*.

Clyde's study should be repeated by other investigators and the results compared. Before one can build upon findings obtained from one researcher's single study, others should witness the same effects.

Questions suggested by the above study include:

1. What are the relative efficiencies of carbohydrate-protein conversion of cattle and fungi?
2. What nutritional dependencies are there between alga and fungus in a lichen?
3. What conditions of temperature, light, and agitation are optimal for maximum growth of fungi in a dextrose-based medium?
4. What are the lines of metabolism that would make one species synthesize protein more efficiently than another?

Effects of Thyroid Removal and Stimulant upon the Reflex Speed of Albino Rats

WILLIAM E. BLANK

Tenth Grade, Shaker Heights High School, Shaker Heights, Ohio. Teacher, Jack D. Miller.
Winner, Silver Plaque Award, Region VII

William had heard and read that the intervals between the stimuli and responses of certain reflexes were influenced by the functioning of the thyroid gland. He learned that the ankle-jerk reflex was used by physicians to diagnose hyper- and hypothyroid cases. For a project, William decided to confirm the relationship between thyroid rate and reflex speed in the knee-jerk reflex of albino rats.

Five young rats from one litter were selected for the tests. The thyroid glands were removed from two rats; thyroid extract was fed to two rats; and one rat was maintained as a control. Measurement and recording of knee-jerk reflexes were accomplished by a self-made apparatus. The knees of anesthetized rats strapped to the machine were tapped. The movement of the responding leg was recorded as a line on a graph on a rotating drum. Readings were made for animals before treatment, two weeks after treatment was begun, and after treatments, when rats were restored to normal thyroid levels.

The young researcher concluded that, "... When thyroid rate is accelerated, reflex speed is likewise accelerated. As thyroid rate is suppressed, reflex speed is slowed down considerably. Correction of thyroid malfunction generally corrects reflex speed malfunction."

One line of research suggested by William's work may inquire into factors that seem to control human reflex speed. Topical questions may include:

1. Does coffee increase reflex speeds equally for all people?
2. On the bases of reflex speeds, what are the safest ages for driving automobiles?
3. What variation in reflex speeds can be observed for an individual over a normal 24-hour period?
4. Can a person be motivated (without the administration of drugs) to increase his reflex speeds?
5. Is there a positive correlation between high reflex speed and athletic prowess? ##

The Effect of Different Factors on the Nervous System of a Cockroach

WILLIAM TILTON

Tenth Grade, LaSalle Institute, Glencoe, Missouri. Teacher, Brother Jeffry Anselm, FSC.

Winner, FSA Regional Award of \$50 Savings Bond, Region IX

Several years ago workers in a jet-engine factory were observed to have sustained severe burns without having been aware of the injuries until after having left the plant. An inquiry revealed that loud sounds were masking the sensations of pain. The phenomenon is called audio-analgesia. Some dentists use this effect with earphones and music for patients wishing to avoid chemical anesthetics and pain.

William may have discovered in cockroaches an effect similar to audio-analgesia. With an oscilloscope and an electrocardiogram, he developed a technique to detect sensory impulses in the nerve cord of roaches when the insects were stimulated by touch, heat, and cold. When roaches were exposed to the sound produced by a middle C-pitched tuning fork, William observed unusual patterns on the screen of the oscilloscope and on the recordings made by the electrocardiogram. Rather than the expected jagged wave pattern, the constant control readings leveled as though the animal were paralyzed.

William has found the phenomenon all the more unusual since, as far as he knows, the roach has no specialized sound receptors. However, his next investigation aims at determining whether additional sound frequencies, to be produced by an audiogenerator, have the same calming effects.

Other lines of investigation may include:

1. Where on the bodies of cockroaches are the areas that are sensitive to sound?
2. Are tedious, painful, or unpleasant human tasks more efficiently accomplished when subjects are listening to music than when complete silence reigns?
3. One hypothesis explaining audio-analgesia suggests that sound and pain centers are located next to one another in the brain. When one center is overstimulated, the other operates less efficiently. The stuttering of a left-handed person forced to change to right-handedness has been explained similarly. How valid is this hypothesis?

The Pituitary Influence Over Frog Coloration

TIM BANNON

Tenth Grade, Shaker Heights High School, Shaker Heights, Ohio. Teacher, Jack D. Miller.

Winner, Silver Plaque Award, Region VII

Tim's science teacher gave him the idea to investigate effects of the pituitary gland on the skin coloration of grass frogs. Tim's specific problem was to determine whether whole pituitary glands, taken from frogs of predominately green coloration and injected into predominately brown frogs, would alter the coloration of the brown frogs. The results of his study indicated a slight modification of color among the injected brown frogs. Tim recognized that color may also be influenced by climatic factors. Future research may direct him to control such variables as temperature and duration of light exposure.

Tim apparently became intrigued by the behavior and the changes in the behavior of the frogs throughout the course of his research. He self-discovered conditioned response. The injected frogs were observed to have exhibited increased motor activity and an ability to learn quickly. Future research may direct him into animal behavioral studies. Tim has now developed certain basic skills in hormone research and techniques of maintaining healthy environment for frogs.

The Effect of Colored Lights and Colored Backgrounds on Chameleons in an Expanded Melanophore State

CATHY JEANNE SPITZ

Tenth Grade, Shaker Heights High School, Shaker Heights, Ohio. Teacher, Miss B. Jaksa.

Winner, \$50 Savings Bond Award, Region VII

There are a number of kinds of animals which change color in accordance with environmental conditions. The color of the pelt of the arctic hare changes with the season; squid and octopi, when disturbed, will flash color changes in beacon-like fashion; and the color of a grass frog can usually be intensified with light and reduced with darkness. The phenomenon of color change in animals is popularly associated with the chameleon. In this country the lizard *Anolis carolinensis* (an iguanid) is noted for its color-changing responses.

When the pigment-bearing bodies (melanophores) of the anolis are contracted, the animal appears to be green. Fully expanded melanophores produce a dark brown coloration. The animal is usually green in an excited state, in darkness, and at death. Full-body illumination and low temperature are conditions that will cause melanophores to expand, producing the brown color.

In a series of experiments, Cathy first established, for purposes of control, the responses of an anolis to white light when placed on white and black backgrounds. She found that an anolis placed on black backgrounds and exposed to white light turned brown, while an anolis placed on white backgrounds under white light turned green. She then observed that an anolis placed on backgrounds of various colors changed from the expanded melanophore state (brown) to green most completely when the background was red, decreasing up the spectrum to blue where the reaction was least. A brown anolis placed on black backgrounds and illuminated by lights of various colors, made slight color changes, reacting in greatest measure to yellow light.

There are at least eight factors that control color in lizards: age, sex, season, temperature, state of excitation, health, light, and color of environment. Many questions can be asked about individual factors and combinations of factors. Regarding light and backgrounds, in addition to Cathy's questions, one might question the extent to which color changes are differentially determined by stimuli received by optic light receptors and skin receptors.

The Effect of Varying Concentrations of Detergent on the Survival of Fish

SAMUEL MALAYAN

Tenth Grade, Berkeley High School, Berkeley, California. Teacher, J. C. Nash.

Winner, Silver Plaque Award, Region XII.

Synthetic detergents, though desirable in the home and in industry, contribute in major fashion to our problems of water pollution. These chemicals when contained in disposed waste, do not sufficiently break down to prevent foaming, the destruction of aquatic

life, taste and odor problems, difficulties in coagulation and settling. The use of detergents is increasing in the United States at the rate of 5 percent a year. Considerable study is needed on the degradation of detergent compounds in sewage treatment plants. Also important is the need to learn of the toxicities of detergents, their components, and their form after treatment.

Samuel undertook a bioassay of three detergent components and one commercial detergent. He measured the rates of survival of 180 goldfish at four concentrations. He found that goldfish are more tolerant of detergents than are trout, fat head minnows, and tadpoles, as reported in the literature.

Samuel further noted in his results that a chain compound component of detergents was significantly more toxic to goldfish than a cyclic component. The cyclic compound is to be replaced by the chain compound in commercial detergents, because the latter is easily broken down by the sewage treatment process. He speculates that unless the chain compound is more than three times as degradable as the cyclic compound, the residue of treated effluents might be as toxic as the effluents for detergents containing the cyclic compound. He notes that more study of the biological effects of treated effluents is needed.

Additional investigations about pollution by synthetic detergents may seek answers to the following questions:

1. What animals other than vertebrates can be used to detect toxicity levels of detergents?
2. With what physiological processes in fish do detergent toxicants interfere?
3. Which sewage treatment organisms are most effective in the degradation of effluent sewage?
4. Can synthetic detergent wastes be chemically or physically treated to reduce bothersome odor, taste, foaming characteristics?
5. What are the differences among the commercial synthetic detergents in regard to their
 - A. Surface tension properties?
 - B. Abilities to dislodge and hold in suspension dirt and soil clumps?
 - C. Chemical compositions?

The Effect of Light on Endogenous Rhythms in *Blattaria*

ROGER BARTLETT SWAIN

Tenth Grade, Belmont Hill School, Belmont, Massachusetts. Teacher, Robert B. Worrest.

Winner, Silver Plaque Award, Region I.

This project was a study of the regular variations in the behavior of cockroaches. The rhythms investigated were ones reportedly caused by internal rather than external forces. The periodicity of activity as measured in the frequency of body movements was observed under the following conditions of light: (a) a "normal day" of 12 hours of light and 12 hours of darkness, (b) continuous light, (c) continuous darkness, and (d) a reversal of the normal day. The roaches' rhythms of activity established in (a) were identical under conditions in (b), but of less intensity. Continuous darkness caused the cycles of activity to spread over a two-day period. Reversing the day caused the roach to develop two periods of heavy activity each day. Roger concluded from these data that it is possible to set the internal clock of a roach with light-dark periods and then depend upon the animal as a living timepiece.

The mechanisms for detecting and recording cockroach movements functioned satisfactorily. The bottom of the cage was lined with two concentric circles of metallic tape. When the animal bridged the gap (even with a leg), a penned record was made on a constant-speed paper tape.

Before anyone undertakes an investigation, he is expected to search the literature for background knowledge and ideas about procedures and techniques. Following is a list of references that can help prepare persons for investigations on the topic of biological clocks.

- Erwin Bunning. *The Physiologic Clock*. Academic Press, New York. 1964.
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- J. L. Cloudsley-Thompson. *Rhythmic Activity in Animal Physiology and Behavior*. Academic Press, New York. 1961.
- Donald S. Farmer. *Photoperiodism in Animals*. BSCS Pamphlet No. 15. D.C. Heath and Company, Boston. 1964.

R. B. Withrow (Editor). *Photoperiodism and Related Phenomena in Plants and Animals*. American Association for the Advancement of Science Publication No. 55, The Association, Washington, D.C. 1962.

Phototaxis in *Euglena* Cultures

DANIEL CARRILLO

Ninth Grade, Mt. St. Joseph Academy, Rutland, Vermont. Teacher, Sister M. Helena, S.S.J.

Winner, Silver Plaque Award, Region I and

Photosynthesis in *Euglena*

THOMAS W. FINDLEY, JR.

Eleventh Grade, Lyons Township High School, LaGrange, Illinois. Teacher, Donald Axelson.

Winner, Silver Plaque Award, Region VIII

Each of these studies deals with an organism that is ideal for many scientific investigations. Most species of *Euglena* are easy to cultivate and observe and are always fascinating to secondary school students. The apparent discrepancy between the organism's abilities to photosynthesize and to move freely is provocative to all levels of scientific sophistication.

Euglena are of current interest to full-fledged scientists, as is evidenced by "Pressure-Induced Color Mutations of *Euglena gracilis*," J. A. Gross in *Science*, February 12, 1965, and in "The Amateur Scientist," C. L. Stong, *Scientific American*, October 1964.

The latter article was used by Daniel in his study as he modified some of the experimental techniques described in it. He investigated the effects of mineral salts on the phototactic response of *Euglena* and found that "... the salts most effective in promoting phototaxis and aggregation were, in descending order: phosphorus, nitrogen, and potassium."

Thomas investigated the growth rates of *Euglena* cultures. A key procedure in obtaining data was the development of a rapid method for estimating population densities. This was accomplished by measuring the optical densities of cultures with a spectrophotometer. The validity of this indirect method was established by comparing direct microscopic counts with observed optical densities and from consultation with a professional scientist. Thomas found that light of 580 millimicrons was most reliable and that optical densities were

proportional to population densities.

This study was actually an outgrowth of a project previously done by other students at the school. As such it illustrates the value of teachers' maintaining files of past studies for student use. This practice, in a way, parallels that of professional scientists' extending the investigations of colleagues.

The report, as written by Thomas, presents considerable data but little in the way of specific conclusions. In one phase of his study he bubbled certain pure gases through different samples of culture media prior to inoculation with *Euglena*. He then determined population densities for the next 30 days. The gases used were nitrogen, carbon dioxide, and oxygen. He reported that each culture showed some population increase though "not very much." He felt that the growth in the nitrogen saturated culture was totally unexpected and unexplained.

Verification of the findings from each of these studies would form the bases of good experimental investigations. In addition, each investigator, from his background reading, reported some interesting statements about *Euglena*. Each statement may suggest a separate investigation.

1. "*Euglena* can be made to lose their chloroplasts permanently by being exposed to streptomycin or pyribenzamine."
2. "It has also been noted that *Euglena* have cycles. For 12 hours they will not be attracted to the light, but for the next 12 hours they will be."
3. "No medium has yet been found which would prevent green cells from losing their pigmentation when placed in the dark."
4. "Light intensity from 0 to 150 foot-candles has no discernible effect on the rate of growth in an organic medium."
5. "When unfavorable conditions arise, it (*Euglena*) encysts. This cyst is able to survive drought or cold and later germinates to form 4 to 16 daughter cells."

This reviewer was amazed to find *Euglena* thriving in the digestive fluid of pitcher plants (*Sarracenia purpurea*) growing in an Ohio bog. A few other protists and rotifers were found in the same fluid. Samples of this fluid have been kept in a little-used refrigerator

for nine months, and the green color has persisted though the *Euglena* has apparently encysted and individuals clumped together.

Sensitivity in Venus' Fly-Traps

MARY ANN TAVERY

Eleventh Grade, Dominican High School, Detroit, Michigan. Teacher, Sister Gerald Cecilia, O.P.

Winner, Silver Plaque Award, Region VII

The Venus' fly-trap is one of the few plants that move with perceptible speed. As such it is fascinating to almost everyone. Once having seen it move, almost everyone asks questions about it.

This investigator proposed several specific questions for study after some preliminary observations. She noted that when an object "... was merely dropped into a gaping trap, the trap remained open. Yet if the object was moved around, the lobes swept shut instantly." This led her to hypothesize that "multiple stimuli" are necessary to trigger the closing mechanism. She found that this hypothesis is, in fact, valid.

It was found that only certain hairs within the trap triggered closure. For purposes of experimentation, a steel needle was used to twitch sensitive hair. One twitch was assumed to be one stimulus.

Further, she found that the number of stimuli necessary to trigger closing is dependent on temperature. At 12°C at least three stimuli were needed, while at 22°C two were sufficient. At 35°C no number of stimuli would trigger closure.

Working at room temperature (20°C), the investigator found that the time interval between the two stimuli needed affected the speed with which the trap closed. For instance, "when the time interval between stimuli was less than one second, about one second was required for closure. When 20 seconds elapsed between stimuli, complete closure required 2 seconds. When intervals between stimuli exceeded 22 seconds, no closure occurred.

As with all first-reported findings in science, this investigator's work should be repeated by other experimenters to insure the validity of the findings.

Many further studies stemming from this one may well be directed to the

larger problem of learning the mechanism by which Venus' fly-traps move. One could investigate questions such as: What physical factors, if any, affect the opening rates of traps? Are electric phenomena associated with closing and opening? Could movement of water within the plant provide the force for opening and/or closing the fly-traps?

Protective Effect of Serotonin Against Gamma Radiation

EILEEN THOMPSON

Eleventh Grade, Ottawa Hills High School, Grand Rapids, Michigan. Teacher, Anna F. Nelson.

Winner, FSA National Scholarship of \$300 and Special Award of \$200 from the American Dental Association

This study involved a clear-cut hypothesis: "Injections of serotonin will protect rats from the effects of gamma radiation." The study evolved from a previous study in which it was noted that certain tranquilizers decrease the amount of serotonin naturally present in animal organisms. Reserpine is the specific tranquilizer cited.

The hypothesis was tested by radiating three groups of rats with 800-roentgens of gamma radiation from cobalt 60. Group 1 was untreated prior to radiation. Group 2 was injected with 2 milliliters of isotonic saline, 30 minutes before irradiation. Group 3 was injected with 3 mg of serotonin in the creatine sulfate complex dissolved in 2 ml of the isotonic saline solution 20 minutes before irradiation. All injections were made into the abdominal cavity. A hospital facility was used for irradiation. The serotonin injections lowered the 30-day mortality rate from about 72 percent to about 13 percent.

The experiment made notable use of control groups and group sizes (16) which added a measure of reliability to the results. The project also illustrates the kind of cooperation that is often available from industrial and civic organizations.

Possible questions for other investigations:

1. How long does the protective effect of injected serotonin continue?
2. Do compounds structurally similar to serotonin produce similar results?

3. Does injection of reserpine, or other tranquilizers, increase the lethal effects of gamma radiation?
4. Does serotonin produce the same effects on organisms which are irradiated with X rays and/or beta rays?
5. Are there chemicals which can reduce erythema (sunburn) from ultraviolet radiation?
6. Do plants contain serotonin or some analogous compound which changes the effects of ionizing radiation?

Modification of Plumage Color in Domestic Pigeons

LEE SNYDER

Eleventh Grade, Huron High School, Huron, South Dakota. Teacher, Richard D. Vitters.

Winner, National Scholarship Award of \$300

When feathers of pigeons are repeatedly plucked in 40-day cycles, the regenerated feathers of birds of certain colors have been observed to be lacking in pigment. The causes of the phenomenon, called "pigment-cell failure," are unknown.

Lee Snyder has been testing hypotheses over a three-year period, obtaining subjects from his colony of 120 domestic pigeons. Early in his studies, he discovered that neither enriched nor deprived diets influenced pigment-cell failure. Yet, knowing that certain proteins are essential to the formation of melanin, he attempted to alter pigment-cell formation by feeding pigeons the melanin suppressor, phenylthiourea, PTU. Although PTU induces a reversible graying in black rats, there were no effects upon the pigeons that markedly exhibit pigment-cell failure. PTU did induce fading in the plumage of black-and-blue-bar pigeons. Lee is currently in the process of discovering whether the fading is reversible in these birds. The entire project of developing ways to modify plumage color has also introduced him to specialized problems in histology, genetics, chemistry, and physiology.

Possible questions for other investigations:

1. What relations exist between illumination of the body and the development and distribution of pigment and chromatophores of fish, amphibians, reptiles, mollusks, and insects?
2. To what extent, if any, do body

surface temperatures affect the deposition of pigment in the hair follicles of mammals?

3. Chlorophyll will fail to develop in grass leaves growing beneath a board. Does this mean that the green pigment will not develop in any green plant that is maintained in darkness?
4. Are albino plants completely insensitive to light?
5. Coat color in mice is determined by many genes. How many of these alleles can be discovered by students beginning with a parent population of white mice and mice with agouti pattern?

The Effects of a Vitamin A Deficiency on Blood Serum Proteins

GILBERT RAFF

Eleventh Grade, Abraham Lincoln High School, Brooklyn, New York. Teacher, Mr. P. Goldstein.

Winner, Silver Plaque Award, Region III

Clinical effects of Vitamin A deficiency include night blindness, increased susceptibility to infectious diseases, and arrest of growth. As biologists know, these effects are merely secondary consequences of more specific and fundamental effects of the deficiency.

Gilbert read that Vitamin A is essential for tissue protein growth—not protein maintenance. If the vitamin were essential for protein maintenance, deficient organisms would be expected to lose weight rather than merely stop growing. He found nothing about the effect of Vitamin A on the serum proteins which he understood to be the source of the body's tissue proteins. What happens to the serum proteins (alpha, beta, and gamma globulins and albumin), as organisms manifest the Vitamin A deficiency syndrome? This became the question he proceeded to answer.

Twenty male hooded rats were involved in the controlled test. To obtain weekly samples of blood, Gilbert invented a suction apparatus for obtaining measured amounts of blood from the rats' tails. Serum was separated into the various protein fractions by electrophoresis. By elution he was able to measure the relative quantity of each fraction. He found that there was no change in the total amount of serum proteins. However, the relative quantities of the serum proteins changed sig-

nificantly. Albumin and gamma globulins decreased, and beta globulin increased. The reason for an increase in beta globulin is now an even more puzzling question for Gilbert than was the question that led him into this biochemical inquiry.

The search for answers to scientific questions usually leads to harder, more exciting, more significant questions. A test of the effectiveness of a research experience is the ability of the student to explicate such questions.

Effect of the Drug Dexedrine on the Metabolism of Four Vertebrates

CAROL ANN TIMA

Eleventh Grade, Marymount High School, Garfield Heights, Ohio. Teacher, Sister Mary Leanne, S.S.J. Winner, Silver Plaque Award, Region VII

The aralkylamines are a group of aliphatic amines with powerful physiological effects. Epinephrine and norepinephrine when injected intravenously cause a rise in blood pressure owing to constriction of blood vessels and increased heart action. Also noted are dilation of the pupil of the eye, dilation of bronchial passages, and a decrease in digestive activity. Claims have been made that epinephrine is released from the adrenal glands in greater volume when the body demands increased vigilance and self-control, while norepinephrine is the hormone for anger and combat. Other compounds of this group include mescaline, found naturally in buttons (peyote) on the flowering head of a cactus and known for its effects of producing exhilaration and strong hallucinations in color; ephedrine, the original nasal decongestant; and amphetamine, a stimulant of the central nervous system capable of arousing persons from sleep induced by narcotics. Under prescription, amphetamine, as well as Dexedrine or Benzedrine, is used to control appetite, to stimulate wakefulness, and to counteract psychic depression.

Carol Timma wanted to find out how Dexedrine differentially influenced the metabolic rates of a mouse, a parakeet, a turtle, and a frog. For each organism she determined respiratory quotients before and after injection of Dexedrine. Results were inconclusive. She surmises that Dexedrine increases the rates of metabolic processes in mammals and possibly in birds, but has no effect on

reptiles and amphibians. The study should be repeated by Carol and by other investigators. Other representative organisms should be tested.

The physiological and psychological effects of aralkylamines on non-human subjects can be an effective vehicle for student investigations. However, *these chemicals are under federal control. Students must work under professional supervision.* Sample questions for investigations include:

1. Does Dexedrine affect the activity rhythms of laboratory mammals? Does a tolerance to Dexedrine build up in those animals that do demonstrate an observable physiological effect?
2. What are the observable circulatory, respiratory, nervous changes of animals in response to injections of epinephrine? Does a phylogenetic series of animals respond in any graduated way as may be inferred from Carol's report regarding the effects of Dexedrine?
3. A library project of merit might be concerned with the problems of drug nomenclature. What are the laws and procedures that control the assignment to drugs of proprietary (trade) names, nonproprietary trivial names, and systematic names?

Seed Germination Inhibitors in Nature

AUDREY ANDERSON

Twelfth Grade, San Bernardino High School, San Bernardino, California. Teacher, Van Hainline. Winner, Silver Plaque Award, Region XII

Have you ever wondered why seeds do not ordinarily germinate within the parent fruit? Certainly there is moisture enough, and fruits are frequently maintained within a temperature range favorable for germination. Perhaps the percentage of available oxygen is below the threshold required for the rapid activities of germination. Possibly exposure to light triggers germination.

Through reading, Audrey found that the pulp of certain fruits contains a substance (or substances) that prevents germination of contained seeds. She also read that the seed coats of hard wheat seeds contain a germination inhibitor that not only delays the

germination of its own seed, but will also inhibit the germination of the seeds of neighboring plants.

Audrey's research project evaluated the effects of certain plant extracts as inhibitors of seed germination. Seven kinds of seeds were "watered" with the water-soluble extracts of nine plant substances suspected of containing inhibitory agents. For control, each kind of seed was also treated with pure water. More than 70 individual containers were simultaneously involved in this experiment. One result of the study indicated that lemon rind extract markedly inhibits germination of zinnias, radishes, and peas and has little, or no, effect on the seeds of corn, sunflower, morning glory, and bean.

The control and prediction of the phenomenon of seed germination are complex problems. Each kind of seed seems to have its own set of optimum external and internal conditions for germination.

A student wishing to understand better the phenomenon may address himself to the following topical questions:

1. *Water supply.* How much water, expressed as percent of original weight, will mature, dry seeds take up? How is the rate of water uptake related to external temperature? How much pressure is exerted by the endosperm and embryo as they absorb water and break through the seed coat?
2. *Temperature.* What are the upper and lower limits for germination of specific seeds such as peas, lettuce, radishes, and corn? What temperature extremes can dormant seeds undergo and still retain viability?
3. *Oxygen.* Can the rate of germination of seeds be increased by enriching the supply of oxygen? Can dormant seeds survive in the absence of oxygen? What is the rarest atmosphere in which seeds will germinate?
4. *Light.* Is the effect of light on germination essentially the same for all seeds? Although Kentucky bluegrass germinates better in the light than in the dark at constant temperature, will it germinate well in darkness when temperatures alternate from high to low? How would you account for this phenomenon in the first place?
5. *Chemical stimulant.* Audrey studied natural inhibition of germination. Are there chemical stimulants of seed germination?

Development, Isolation, and Analysis of Unknown Growths of Nitrogenated Rye Grass

CARL R. KONKEL

Twelfth Grade, South Division High School, Milwaukee, Wisconsin. Teacher, Orlando Nelson.

Winner, Silver Plaque, Region IX

The "nitrogenated rye grass" in this study refers to rye seedlings that were germinated in a water-vapor-saturated atmosphere of 97 percent nitrogen and 3 percent oxygen. The unknown growths were fuzzy black nodules that formed on the grass seedlings.

The investigator attempted to identify the nodules, with no positive success. His results are given here to serve as a guide for other investigators who might extend the study.

- A. The nodules appeared at nitrogen concentrations as low as 84 percent, but not when air was used. This might suggest that spray from the nitrogen-generating reaction has an effect.
- B. The nodules were placed on a wet bread culture, but nothing happened. This was interpreted as a negative test for mold. However, the fuzzy characteristic of the nodules would suggest that further mold tests are in order.
- C. Several "nitrodes" were boiled. The residue "had no acidic or basic properties."
- D. The seedlings absorbed safranin stain, but there was no clear evidence that the nodules did.
- E. Several nodules were placed "in a Milorganite[®] culture to see if they would be nourished by the mineral content." The nodules did not change.

The chemistry-class origin of this study is acknowledged by the investigator. It is interesting to note that the teacher was probably alert to an opportunity to emphasize the interdisciplinary nature of science. In this case biology and chemistry certainly came together. One of the characteristics of good science teaching is the integration of present subject matter with that from previous courses. In this

case, the effort "caught" one of the students and led him to a sample of the excitement of discovery that is inherent in science.

The Comparable Effect of Growth-Promoting Substances in Soybean Seeds to Commercial Gibberellin on Ratican Gardenias.

GALE FUMIE HAMAOKA

Twelfth Grade, Kaimuki High School, Honolulu, Hawaii. Teacher, Alvin Won.

Winner, Silver Plaque, Region XI

The exact class activity that stimulated this investigator was not described in the report. However, there have been numerous items in newspapers and scientific journals that describe experiments with growth-promoting substances. Possibly this investigator's science teacher brought these articles to the attention of the class, thus linking science class activities with the modern world.

In this investigation, crushed seeds of soybeans were extracted with an acetone-water (4:1) mixture for a period of 24 hours. Subsequent extraction procedures were conducted to isolate gibberellin-like substances. (Details of this procedure and subsequent analysis of data can be found in "The Amateur Scientist," *Scientific American*, August 1964.)

The final extract was dissolved in acetone-water (1:1) mixture and applied topically to the leaves of one group of five gardenia seedlings. Another group of five seedlings was treated similarly with a water solution of "gibberellin, commercially made." A control group of five untreated seedlings was also maintained.

Ten days after treatment, leaf measurements were compared to those made before treatment, using care to find statistically significant differences.

The principal conclusion made from the data was that soybean seeds contain gibberellin-like substances, in that these as yet unidentified substances produce results similar to those produced by commercially distributed gibberellic acid preparations.

The following items could be considered for further study:

1. Maybe the solvent (water), rather than the solute of the solution sprayed on the leaves, was responsible for increased growth rate. (In this study, the control plants were not sprayed at all.)
2. Could the growth-promoting substance occur throughout the plant instead of only in the seeds?
3. Several other studies have reported that extracts from cantaloupes, peas, cucumbers, and other plants have promoted growth of test plants. In fact, this reviewer has never seen such a study in which the plant extract didn't accelerate growth. Could these growth substances occur in all plants? Is it possible that the experimenter's "wishes" were the real cause for growth acceleration?

Seasonal Variations in Natural Populations of Algae

KAREN LANG

Twelfth Grade, Winter Haven Senior High School, Winter Haven, Florida. Teacher, Evelyn Hughes.

Winner, Silver Plaque Award, Region VI

Seasonal changes in rivers and streams are apparent to even the least sophisticated observer. In many areas, these changes are of great concern to the communities through which they flow. The physical destruction of floods is spectacular but is probably more easily controlled than are some of the other seasonal variations, such as the one investigated by Karen Lang.

"There have been chronic problems with algae at the mouth of the Alafia River . . . [yet] lack of personnel has prevented any intensive study of algae growth. No correlation had ever been attempted between algae growth, seasonal cycle, and chemical constituents in the samples routinely checked in the laboratory (maintained by the Florida State Board of Health)."

Karen obtained data on river water samples "for the approximate quantity and type of algae." At the time of writing her report, the study was not completed. However, on the basis of the available evidence she believed that "due to the presence of a highly

acid content along with a fairly high phosphate content, the *Cyanophyta* species are more apt to be present in rather abundant quantities."

Rivers constitute a valuable natural resource of beauty, utility, and recreation. However, the magnitude of a large-scale river study requires a team effort. If your school community is on a river, consider the possibility of teaming up with other schools in both upstream and downstream communities to study the weekly or daily variations in algae. As was emphasized in Karen's study, there are many variable factors such as temperature, turbidity, pH, dissolved oxygen, etc. A science class or club could have each of its members specialize in one factor and then pool all its data and attempt to find correlations or cause-and-effect relationships. Needless to say, any or all science disciplines could be utilized, because a river has chemical, botanical, physical zoological, geological, and other aspects.

If cooperating groups upstream and downstream are formed, a natural consequence could be a "Regional Conference on the [local] River." Aside from the obvious public relations value of such an undertaking, it would represent one real aspect of the scientific enterprise today.

**Physical Environmental Control
—The Effect of Altitude on
the Albino Rat**

DAVID E. SMUCKER

Twelfth Grade, Wheaton Community High School, Wheaton, Illinois. Teacher, Wesley A. Dusek. Winner, FSA National Scholarship of \$300

Studies comparing adaptation to altitude of Peruvian natives living at sea level and at 14,900 feet have stimulated much research and some controversy. Humans acclimated to high altitudes have developed higher red blood cell counts, larger hearts, and a greater number of capillaries than have humans living at lower altitudes. Characteristically, persons so adjusted to high altitude living have great ability to work in hypoxic conditions. Since this adaptation can be induced by exposure to rarefied air, questions arise as to whether or not astronauts and other persons who may perform under

pressure conditions other than normal may benefit from induced physiological adaptation to pressures greater or less than normal.

David chose to tackle the general problem of whether an organism temporarily acclimatized to high altitude living would actually be done more harm than good. He decided to investigate the effect of prolonged exposure to altitude on the growth rate and red cell count of the albino rat.

The first task was to design and construct an environmental chamber for two experimental rats. After five months of work David completed his "complete physical environmental chamber." With this apparatus, he was able to maintain rats under automatically controlled conditions of pressure, temperature, humidity, and gas content.

The experiment involved four rats for 96 days. During the first 32 days rats were maintained under normal laboratory conditions while periodical weighings and red blood cell counts established base lines. Two rats were exposed for the subsequent periods of testing. For the next 32 days two rats were daily exposed to 23 hours of simulated high altitudes, while two control rats were kept at normal pressures. Observations were continued through a final 32-day post-exposure period. David found that exposure to a simulated altitude of 10,000 feet significantly retarded the growth rate as reflected in weight and greatly increased red blood cell count.

Research such as that undertaken by David is open-ended. Far more questions have been raised than have been answered. Some topics for further study include:

1. Do sustained pressures greater than atmospheric affect red blood cell production and growth rates?
2. Will a 65 percent reduction in the quantity of available O₂ (as occurs at 10,000 feet) while maintaining standard atmospheric pressure result in the same blood and growth effects observed by David?
3. David noticed that during the recovery period, the red blood count dropped below normal but soon rose to normal levels. What causes this "dip effect"?
4. Do organisms work as efficiently or learn as rapidly when adapted to altitude as they do at normal atmospheric pressures?

5. How are plants physiologically affected by pressure changes?
6. Is it possible to carry out studies in plant ecology by duplicating life zones in an environmental chamber?

Findings on the Simultaneous Production by Cells of an Anti-Viral Agent (AVA) and a Halo-producing Factor in Response to Inactivated Viruses

DEBORAH CHASE

Twelfth Grade, Bronx High School of Science, Bronx, New York. Teacher, Kenneth Bobrowsky.

Winner, FSA National Scholarship of \$300

Deborah had been studying aspects of the virus interference phenomenon for six years. The phenomenon that inspired her study of virology was first reported from observations made during the 1930's. Infections in organisms of viruses of one strain were found to offer protection for the organism against infections from other strains of viruses. For example, yellow fever virus of a nerve-infecting strain protects mice against a visceral-infecting strain; flu viruses were used to interfere with viral equine encephalomyelitis; and in human populations where poor sanitation facilities supported an endemic intestinal infection, children were immune to the viruses of polio.

Deborah's award-winning report has resulted from six years of highly specialized laboratory research. Details of her procedures and findings are difficult to communicate briefly. Here is an abstract of her study, however:

A broad-spectrum anti-viral agent, AVA, is produced in bacterial cells in response to virus attacks. When inactivated viruses are used to trigger such attacks, the production of AVA is increased, and the agent can be extracted and used to protect unrelated and related bacterial cells from related and unrelated viruses. Like interferon (a protein molecule with anti-viral action¹), AVA acts in the cells and does not inactivate free viruses. The technique of extracting AVA from bacterial cells might possibly alter its intracellular molecular structure. During the disruption of the cells by sonic vibra-

¹ For further information about interferon, see "Interferon," Alick Isaacs, *Scientific American*, 204: 51-57, May 1961.

tion to free their AVA, lysin is also released into the solution carrying the cells. The lysin produces large, translucent halos around the plaques at the lysis sites of the few host organisms in each test culture which are not protected by the AVA in the AVA-lysin solution. Unlike interferon, AVA is a nuclear protein and can be inactivated by the nucleases, DNAase and RNAase.

Isolation and Characterization of Three Bacteriophages of Genus *Pseudomonas*

EDWINA SMITH

Twelfth Grade, Alamo Heights High School, San Antonio, Texas. Teacher, Marjorie Behringer.

Winner, FSA Regional Award of \$100 Savings Bond, Region X

Edwina became interested in microbiology during her attendance at a summer institute at the University of Texas. During the summer, she learned many microbiological techniques and began this study which was continued during the following school year.

After extensive reading about bacteriophages and virus, Edwina began her project by isolating *Pseudomonas*. She used small samples of soil as a source and incubated inoculations in a "mineral broth containing sodium benzoate." Most bacteria—*Pseudomonas* is a notable exception—cannot utilize benzoates as a "carbon source." This technique led to enrichment of the culture in *Pseudomonas*, and pure cultures were obtained by successive plating of the colonies derived from the broth. Identification as *Pseudomonas* was made positive by microscopic examination, fluorescence tests, stain tests, and pH tests.

Edwina's source of phage was raw sewage which was incubated with a "mixed broth culture of *Pseudomonas*" and then "centrifuged and filtered through a Millipore filter." Drops of the filtrate were placed on various "indicator bacteria," and lysis was looked for. Three phages were identified in the filtrate, isolated by successive platings, and concentrated cultures were prepared.

The next phase of the project was to characterize the phage. Adsorption and "inactivation by heat" were the

two characteristics determined. Edwina recognized that more characteristics needed to be identified.

This study is a good example of the open-endedness of microbiological research, as many questions arise from the work that has been done. The same questions would apply to parallel investigations dealing with other bacteria and other phages.

Typical questions are:

1. Are the phages capable of attacking other genera of bacteria?
2. Can mutant strains of a susceptible genus be found that is resistant to attack by the phages?
3. What other sources of bacteriophages might there be? How about the air as a source?
4. Edwina attempted unsuccessfully to obtain a phage from the same soil samples that produced the *Pseudomonas*. Since most life exists in an environment of "predators," why was no phage present in the soil?

Effect of White and Far-Red Light on Mitochondrial Respirations as a New Explanation for Photomorphogenic Phenomena

MARK WEISS

Twelfth Grade, Coral Gables Senior High School, Coral Gables, Florida. Teachers, Dorothy Gregory and Albert R. Krall.

Winner, FSA National Scholarship Award of \$300

Far-red light (6800-7500 Å) has been known to have many effects on living organisms. One such photomorphogenic effect caused by the light is the prevention of chromosomes split by X rays from rejoining. Normally ATP mends broken chromosomes. Investigators have been attempting to explain how far-red light acted in the cell to prevent ATP from doing its work. One approach included a measurement of the change in organic phosphate as an indicator of the change in energy. Results of these studies have not resulted in consistent sets of conclusions. Mark believed that, since not all energy goes into high-energy phos-

phate bonds but all energy is a result of some oxidation, an investigation of the amount of oxygen consumed by mitochondria would be a more reliable indicator of energy production.

He then isolated mitochondria from rat liver and subjected them to far-red light, white light, and darkness in the Warburg apparatus. White light was found to increase the rate of oxygen consumption relative to dark controls while far-red light inhibited the rate of oxygen consumption relative to dark controls. He further found that the effect diminished as more energy was stored in high-energy bonds. These findings enabled him to conclude that the site of photoresponse is in the oxidizing enzymes rather than in the ATP-forming electron transfer system.

Mark suggests that the inhibition of oxygen uptake by far-red light may provide new explanation for such photomorphogenic effects as the prevention of rejoining of split chromosomes, the control of seed germination and plant flowering, and the stimulation of photosynthesis.

CHEMISTRY AND PHYSICS

The Theory of Magnetism

PAUL ZIMMERING

Eighth Grade, Meyer Levin Junior High School, Brooklyn, New York. Teacher, Franklin Gray.

Winner, FSA Regional Award of \$25 Savings Bond, Region III

This is an example of a project that is mainly the library research type. Paul had thought and read extensively about the nature of magnetism. He found that magnetism is currently explained by two theories, the molecular theory and the domain theory. Each conceptual scheme offers explanations for magnetic phenomena he had observed. Throughout his study he confirmed, through laboratory exercises, the existence of certain phenomena that supported the domain theory. At the time he submitted his report, he was pursuing further supportive evidence for this new theory.

The molecular theory of magnetism pictures each magnetically permeable object in its unmagnetized state as having its molecules disoriented. The forces of attraction and repulsion associated with the spinning electrical charges of each molecule cancel one another. When the object becomes magnetized, the molecules are believed to line up with north poles facing one direction and south poles the opposite direction.

The domain theory of magnetism pictures small regions or domains of atoms within a magnetic object. Within each domain all atoms are oriented alike, but differently from atoms of adjacent domains. Domains are separated by transition layers of intermediate orientation. When put in a magnetic field, the specimen tends to show its own magnetic field as oriented domains grow at the expense of other domains.

One can proceed to evaluate these theories through investigations that seek answers to the following questions:

1. Since domains are believed to have linear dimensions of about 0.001

centimeters, what techniques can be developed to observe them?

2. The Barkhausen Effect occurs when a ferromagnetic substance is made the core of a coil. When placed in a gradually increasing external field, the coil serving as a transducer for a high-gain amplifier will produce clicks in a loudspeaker. Do these clicks represent growing domains? How can the answer be tested?
3. What phenomena explained by one theory are not explained by the other?
4. Are there any magnetic phenomena about which there are no theoretical explanations?

Traction and Different Wheel Drives

SCHUYLER METLIS

Eighth Grade, Meyer Levin Junior High School, 285, New York, New York. Teacher, Franklin Gray.

Winner, Silver Plaque Award, Region III

The problem in this study was to determine what wheel or combination of wheels provides the best means of applying driving force for a four-wheeled cart. Equipment used included an inclined plane and a simple cart constructed from Erector set parts and powered by an electric motor from the same set. Power transmission was accomplished by a rubber band belt drive.

The experimenter tried unique combinations of power application, such as through the front left and right rear wheels. Simplicity of apparatus minimized influences which could have distracted the experimenter.

In the actual experimentation, the cart was sent up the incline and its time of travel was measured. Miscellaneous qualitative observations were made. The results were generally inconclusive, but might have been more significant if variables such as belt tension could have been controlled more closely. More quantitative observations would have helped.

This seems to be a study that merits repetition by other investigators who can produce the refinements suggested above.

The Effects of Moving Electrons on Radiation

JACK LAMPL

Ninth Grade, Byron Junior High School, Shaker Heights, Ohio. Teacher, John Wallace.

Winner, Silver Plaque, Region VII.

This investigator reports that the flow of electrons through aluminum foil decreases the penetration of beta and gamma radiation through the foil. This finding is in accordance with his hypothesis which is based on the fact that beta particles and electrons have similar electric charges and should repel each other.

Data was obtained from relatively simple apparatus in which a radioactive source (P-32 for beta or Ba-133 for gamma) was placed on one side of a 30-cm square of aluminum foil mounted in an insulating frame. A thin end window Geiger-Muller tube was placed on the other side of the foil, and radiation intensity was measured by making instantaneous readings of the count-rate meter.

A transformer provided a variable current (presumably a.c.) to the metal foil. The table shows the data obtained using the beta source.

Radiation intensity at varying levels of current

FC	N	Avg	Max	Min
0	18	3.0	4.0	1.5
1	36	2.7	3.5	1.5
2	36	2.4	3.5	1.5
3	36	2.4	3.0	1.5
4	18	2.1	2.5	1.5

FC = foil current in amperes

N = number of individual meter readings
Avg = average of N count-rate meter readings (arbitrary units)

Max = maximum count-rate meter reading (arbitrary units)

Min = minimum count-rate meter reading (arbitrary units)

This is the kind of study that could be replicated and improved without losing the spirit of true inquiry. Specific

features to include in a replication would be:

- Use a scaler with the GM tube so that more accurate measurements of radioactivity could be made.
- Examine the data critically and apply mathematical tests for significance. (See *Experimentation and Measurement* by W. J. Youden in the NSTA Vistas of Science series.)
- Correct data for background radiation intensity.
- Determine radiation intensity of the source without the shielding foil.

In addition to making improved replication studies, one could investigate the following related questions:

- What happens to the beta and gamma radiation? Is it reflected or absorbed? or neither or both?
- Does an electric current through salt water affect the water's transmission of beta radiation? light? infrared radiation?
- Does the experimenter subconsciously affect the data gathered when the experimenter knows what the hypothesis is?
- If the electric current shielding effect can be reproduced, does the thickness of the foil have any effects?

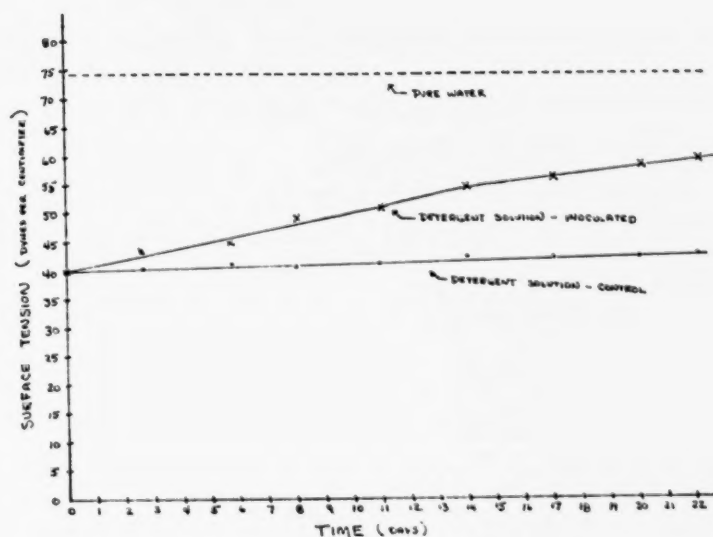
Biodegradability of Sodium Alkane Sulfonate Based Detergents

BARBARA HAMPTON

Ninth Grade, Northwestern Junior High School, Natchitoches, Louisiana.
Teacher, Mrs. M. J. Cousins
Winner, Silver Plaque Award, Region X

This experimenter has obtained evidence of a very interesting phenomenon. She found that a solution of "sodium alkane sulfonate" inoculated with *Pseudomonas aeruginosa* bacteria underwent an increase in surface tension over a period of three weeks.

The detergent solution was made by dissolving $\frac{1}{8}$ teaspoon of Tide in 2 cups of "nonchlorinated water." A "loopful of *Pseudomonas aeruginosa* from stock culture" was added. This technique produced a solution with surface tension of 40 dynes/cm (compared to water which tested to be 74 dynes/cm). When the solution was covered and allowed to stand at room temperature for three weeks, the sur-



face tension (as measured with a Du-Nuoy Tensiometer) increased to 59 dynes/cm. If graphed, the experimental data produce the following:

The investigator chose to interpret the change in surface tension as a result of the complex sulfonate compounds being degraded (metabolized) by the bacteria. This may be the case, but one could argue that the shape of the curve of the inoculated solution would be different if the bacteria population increased.

Further experiments showed that when chlorinated tap water was used the surface tension curve rose more gradually.

If an instrument for accurate surface tension measurement is available and if facilities for controlling temperature, light, and other factors are avail-

able, many extensions of this investigation look promising. For instance,

- Can the results of this investigation be replicated?
- If continued for a longer period of time, would the surface tension of the test solution ever reach that of pure water?
- What effect does temperature variation have on test results? (In fact, does temperature have an effect on the surface tension of pure water or any other liquid?)
- What effect on surface tension is produced by adding culture media (without bacteria) to the detergent solution?
- Dissolving most substances in water raises its boiling temperature. Is surface tension affected in an equally regular and predictable manner?

The Solar Cell

CRAIG KLOSE

Ninth Grade, Hampton Bays High School, Hampton Bays, New York.
Teacher, Alice Squires.
Winner, Silver Plaque Award, Region II

Craig assembled a Solar Energy Experiment kit that was given his teacher by the Bell Telephone Laboratories. The 91-page manual¹ that accompanies each kit provides considerable general background information about solar energy, related theory on the properties of semiconductors, and suggested tests and applications for the solar cells the students make.

Specifically, Craig even went beyond the scope of the manual by comparing the performance of his solar cells with

¹ Daryl M. Chaplin. *Energy from the Sun*. Bell Telephone Laboratories, Inc., New York, New York. 1962.

a commercial variety he purchased. He compared cells with regard to:

- Response to different colors of light
- Response to infra-red light
- Response to sunlight at different times of the day
- Response to white light at varied distances

When the science project is defined as an experience in scientific methodology, the mere assembling of a kit does not qualify. Students, as did Craig, should use their newly acquired knowledge, skill, and apparatus to uncover new knowledge. Kit construction of airplanes, telescopes, computers, or radios qualifies as science project work when the student uses the "packaged experience" as a springboard for inquiry.

Inquiry based on the kit construction of a reflecting telescope may include tests of quality and later astronomical studies, as for example:

1. How far from the ideal telescope does the constructed one depart with regard to:
 - a. curvature of mirror
 - b. precision of clock drive
 - c. amount of light reflected from mirror and transmitted through eyepieces?
2. At what velocities do sun spots move across the surface of the sun?

Inhibition of Fluorescence

ROBERT HARVEY

Ninth Grade, Northside High School, Atlanta, Georgia. Teacher, W. L. Spencer.

Winner, FSA Regional Award of \$50 Savings Bond, Region VI

The phenomenon of fluorescence involves the emission of light from a substance which is excited or energized by absorbing other forms of energy such as ultraviolet radiation. When the exciting energy is stopped, fluorescence stops.

Theoretically, excitation occurs when absorbed energy causes electrons in given atoms to be raised to a higher energy level. When the electron "falls" back to its ground state, energy in the form of light is emitted.

Solids and liquids, though not all of them, have been observed to fluoresce. Certain elements, present as impurities, apparently cause some otherwise non-fluorescing minerals to fluoresce. These impurities are called activators, though other impurities, notably anions (chloride, nitrate, etc.) diminish (or inhibit) fluorescence.

This study attempted to evaluate the relative inhibiting effect of various anions on normally fluorescent solutions of fluorescein and rhodamine B in water. Quantitative observations were made by means of a homemade fluorometer in which standard solutions of fluorescein or rhodamine B could be compared to similar solutions which were 1-molar (a rather high concentration) impurity. The study showed the "decreasing order of activity of anions in the quenching or inhibition of fluorescence (to be): nitrite, iodide, bisulfate, bisulfite, thiocyanate, sulfite, sulfate, citrate, oxalate, bromide, nitrate, chloride, carbonate, acetate, and fluoride."

Possible questions for other investigations:

1. Does a combination of anions produce a predictable inhibition effect?
2. Do cations produce an inhibitive or enhancing effect on fluorescent solution?
3. What effect, if any, does temperature have on fluorescent solutions, either with or without an inhibitor?
4. What effect, if any, is caused by changing the concentration of solutes?

The Thermal Expansion of Liquids and Their Solutions

JOHN BEARD

Tenth Grade, Lane High School, Charlottesville, Virginia. Teacher, John E. Reitz.

Winner, FSA Regional Award of \$50 Savings Bond, Region V

The expansion of substances, in general, when heated is usually explained by picturing the molecules of the substance as moving faster as the temperature is raised. The faster moving molecules have greater distances between them and thus occupy more space than when they are slower moving (cooler) and closer together. In the case of solutions the dissolved particles (molecules or ions) might be expected to affect expansion.

The rate at which a given substance expands during heating can be expressed by the *coefficient of linear expansion* or by the *coefficient of cubic expansion*. Both concepts were used in this study in an attempt to discover relationships among the properties of solvent and solute and the thermal expansion of solutions. Quantitative observations were made on expansion rates of solutions. The apparatus, which was homemade, consisted essentially of a flask to which a length of 4-mm (ID) glass tubing was attached. The apparatus was placed in a water bath to control temperature.

For nonionic solutions (methanol-water), "the coefficient of expansion . . . [was found to be] . . . a result of the proportional sum of the coefficients [of expansion] for the solvent and the solute." For ionic solutions (copper sulfate—water), the rate of expansion was greater than that of either copper sulfate or water. The results may be explained in terms of the effect of solute particles on the attractive forces between water molecules.

Possible questions for other investigations:

1. Do other nonionic solutes produce the same effects as methanol? Good substances to investigate would be sugar, glycerine, and acetamide.
2. Do other ionic solutes such as sodium chloride and lead nitrate produce the same effects as copper sulfate?
3. Is there a relationship between thermal expansion rates of water solutions and the boiling point of the solution?
4. How do solutes affect the surface tension of the solvent?

Inorganic Analysis by Means of H₂S-Quinol Clathrate Crystals and Their Alcoholic Solutions

MARGARET BONERTZ

Eleventh Grade, Assumption High School, Wisconsin Rapids, Wisconsin. Teacher, Sister Jean Marie, O.S.F. Winner, Silver Plaque Award, Region IX

Most chemistry students become familiar with the precipitation of metallic sulfides by bubbling hydrogen sulfide gas through a solution of the metallic ion. The unpleasant odor of hydrogen sulfide is almost the "trademark" of the chemistry laboratory. These two facts are the source of the problems investigated in this study.

Hydrogen sulfide gas was bubbled through 50 milliliters of a saturated solution of quinol (hydroquinone) in water. Bubbling was continued until the solution was also saturated with respect to hydrogen sulfide. The solution was placed in an ice bath; the crystals formed were filtered and air-dried. These crystals are clathrates of quinol-hydrogen sulfide. Molecules of hydrogen sulfide are trapped within the quinol crystals.

When these more or less odorless crystals are placed in water, the quinol dissolves and releases hydrogen sulfide. This provides a technique for odorless sulfide precipitation of metallic ions.

The investigator used the above technique and attempted to extend it to using various alcohols in place of water for preparation of the clathrate crystals. This was unsuccessful in that no crystals formed, but it met with limited success in that the saturated alcoholic solutions were useful in precipitating sulfides from water solution of metallic ions.

Further studies suggested by this project might center around clathrates since these have been recognized as a distinct class of compounds for only about 15 years.

Specific questions might be:

1. How much hydrogen sulfide can be included (i.e., trapped) in a mole of quinol crystals?
2. What substances can be included in a quinol clathrate? Does molecular size of the substance make any difference?
3. Quinol is 1,4-benzenediol which means that the molecule is simply benzene with (OH) groups replacing the hydrogen atoms on opposite carbon atoms. Would 1,3-benzenediol show the same properties? How about other derivatives of the quinol molecule?

Precipitation of Ferric Hydroxide Sol

ROBERT MANUCK

Eleventh Grade, Martin Van Buren High School, Floral Park, New York. Teacher, Noah M. Rosenhouse. Winner, Silver Plaque, Region III

The idea for this investigation was conceived as a result of an activity in a special chemistry projects class. It is easy to imagine the instructor of this class leading a discussion on colloids and impressing the class members with the fascinating not-quite-solution properties of colloids. Possibly a demonstration of the Tyndall effect or of dialysis was what started this investigator on his investigation. Possibly the moment of inspiration was the teacher's vivid description of the vital place of colloids in living systems, or perhaps it was a filmstrip depicting a municipal water-treatment system in which precipitation of colloids is important.

At any rate, the research carried out dealt with the relative precipitating properities of uni-, di-, and tri-valent anions when added to colloidal iron (III) hydroxide in water.

The principal data were obtained by measuring the minimum volume of electrolyte solutions of known concentration that were required to precipitate all of the iron (III) hydroxide from 20 ml of a dialyzed 0.1 percent colloidal solution. Electrolytes used were sodium chloride, sodium car-

bonate, trisodium phosphate, iron (III) chloride, and calcium chloride. The concentrations of the electrolyte solutions were 1-, 2-, and 3-molar and 1-, 2-, and 3-normal.

All other things being equal, one might predict that electrolyte solutions of the same normality should be equally effective in precipitating colloids. However, it was found that:

- A. 2N sodium carbonate was 1.2 times as effective as 2N sodium chloride and 1.1 times as effective as 2N calcium chloride.
- B. 3N trisodium phosphate was 1.2 times as effective as 3N iron (III) chloride or 3N sodium chloride.

These results may deserve further efforts at explanation. For instance:

1. Are the differences statistically significant? Sometimes scientists in the physical sciences tend to overlook this approach to results, because they sometimes assume almost absolute accuracy of data.
2. Can the differences be accounted for by differences in the percent of dissociation of each of the solutes? The concentrations used are relatively high, and yet the investigator assumed 100 percent dissociation.

Thermoelectricity: The Direct Conversion of Heat into Electricity

BERNARD PETKUS

Eleventh Grade, Brother Rice High School, Chicago, Illinois. Teacher, Brother J. J. Kennedy, FSCH. Winner, FSA Honorable Mention and Special Award of \$100 from the American Society for Metals, Region VIII

and

Stoichiometric Doping of Intermetallic Thermoelements

ALLAN DIVIS

Twelfth Grade, Palo Verde High School, Tucson, Arizona. Teacher, Ken Pearson. Winner, Special Award of \$100 from the American Society for Metals and Regional Award of \$100 Savings Bond, Region XI

These two studies illustrate the principle that many good investigations can be made in the same general field but

at different levels of sophistication. Both studies deal with phenomena in which an electric current is produced by temperature difference in two parts of certain systems.

The system used in "Thermoelectricity" is simply a thermocouple consisting of an iron wire welded to a constantan wire. When heated, a small voltage is produced between the free ends of the couple. To produce larger, more usable currents, the investigator joined 20 of the couples in series on an asbestos frame. When heated "... this combination produced twenty milliamperes at four-tenths volt."

In "Thermoelectricity" other combinations—constantan-chromel and chromel and alumel—were briefly investigated for output compared to the temperature of heating. Another experiment was attempted to demonstrate the Peltier effect. In this, two thermocouples were connected in series and each was wrapped around a thermometer bulb. A small direct current was passed through the series, and both thermocouples produced "Joule heat" but "... the temperature of one couple was greater than that of the other and when ... [the polarity was reversed], the two couples changed roles."

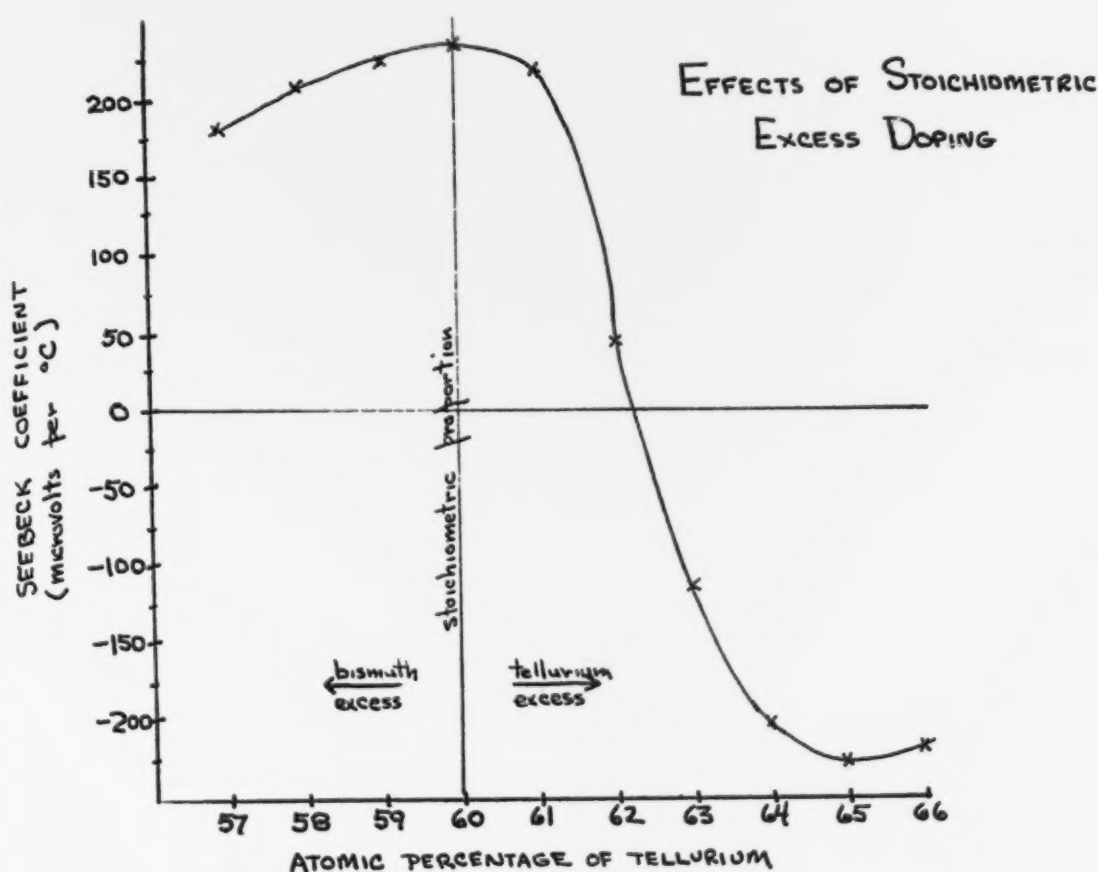
In "Stoichiometric Doping," a single variable in the thermoelectric properties of one material was investigated. In this case a fused mixture of bismuth and tellurium was heated on one side and cooled on the other. The experimenter produced as much as 200 microvolts potential difference between the hot and cold ends of the mass per degree Celsius difference in temperature.

Chemical theory gives the formula Bi_2Te_3 for bismuth telluride. The experimenter mixed 6.94 grams of melted bismuth with 6.36 grams of tellurium to produce this compound (stoichiometric proportions) in which 60 percent of the atoms are tellurium. In subsequent trials the relative proportion of tellurium atoms was increased (to 66 percent) and decreased (to 57 percent).

When the test masses were cooled, each was placed in a homemade testing device, heated at one end, cooled at the other, and the voltage output measured. All data were reduced to volts per Celsius degree temperature difference between the two ends. The accompanying graph shows a unique result.

This second study probes in depth while the first explores many aspects of the same general topic. Each represents a different approach to individual investigations. One can almost visualize a study like "Stoichiometric Doping" to be a follow-up to "Thermoelectricity." Questions related to these investigations might be:

1. What happens to the thermoelectric properties of bismuth telluride when the atomic percentages of tellurium are below 50 percent and above 70 percent?
2. Since selenium is in the same chemical family as tellurium, does bismuth selenide have similar thermoelectric properties? How about antimony telluride? lead telluride?
3. What physical and chemical changes, other than thermoelectric, are brought about by adding an excess of tellurium to a stoichiometric mixture of bismuth and tellurium? Consider hardness, melting point, thermal conductivity, resistivity to corrosion and attack by acids.



The Synthesis of Zeolites

KENNETH M. WILSON, JR.

Twelfth Grade, Tantasqua Regional High School, Sturbridge, Massachusetts. Teacher, Edward Ahern. Winner, Silver Plaque Award and National Scholarship, Region I

In this study the X-ray diffraction unit of a local industrial laboratory was used, and, as is frequently the case, a professional consultant was also available.

The attempt to synthesize zeolite minerals was made in "kitchen" apparatus. To the unsophisticated experimenter, the reaction product probably resembled a mess more than anything else. However, very small quantities of zeolite-like minerals were detectable by X-ray diffraction analysis of the reaction product.

The synthesis procedure was to mix (in order): water, sodium or potassium hydroxides, sodium or potassium aluminate and "Ludox" (colloidal silica-ammonia solution). The proportions of the reactants were variable though the weight of water used was about six times that of the total solids. Some efforts were made to insure that the reactants were present in the proportions of the components in empirical formulas for known zeolites.

The test solutions "were placed in containers and sealed so they were airtight." The reaction mixtures were then "placed in a roaster and cooked for 18 hours at a temperature of 90° centigrade."

"After the solutions had been cooked, they were taken out and the resulting compounds were washed to a pH of 7 and dried."

Interest in studies similar to this one might be provoked by questions such as:

1. What naturally occurring minerals can be synthesized?
2. Zeolites are famous for their ion exchange properties (as is applied on a practical basis in water softeners). Are all ions removed from water solution with equal ease? Or, if different ions are removed unequally, what is the cause of the difference?

Unilateral Electroplating

HARRY F. KILMAN

Twelfth Grade, Wasson High School, Colorado Springs, Colorado. Teacher, Charles E. Riser.

Winner, American Society for Metals Special Award of \$100 and Silver Plaque Award, Region XI

Harry Kilman read in a book of science project ideas that difficulties are encountered when a metal is electroplated to only one side of a thin electrode composed of a different kind of metal. He confirmed the reported phenomenon by noting that when nickel was plated to one side of a brass cathode, the nickel peeled and fell off. When both sides of the brass cathode were exposed to the plating bath, the nickel-plating adhered permanently to the brass, as expected.

In his research Harry attempted to discover conditions that would prevent or reduce the loss of plated metal. He varied voltage, current, and time while he plated nickel on brass and nickel on copper. For all combinations, peeling occurred within an hour and a half after plating. Then, while controlling voltage, current, and time, he added various weak acids to the plating baths. When tannic acid and acetic acid were added, the nickel separated from the copper and brass as before. However, when boric acid was added to the bath, a permanent unilateral plating was achieved.

What role does boric acid play in preventing the loss of plated nickel? Is boric acid consumed in the process? Does examination (microscopic or chemical) of the nickel-copper inter-

face reveal any clues about the role of boric acid?

What happens to a cathode of brass or copper while (or after) it is being plated with nickel on only one side? Do stresses similar to those of a bi-metal strip crack a brittle layer of nickel? Does copperplated nickel behave differently than nickel-plated copper with respect to peeling? Are other combinations of metals difficult to plate unilaterally? Will thin sheets of one kind of metal, which are dipped in molten metal of another kind so as to be coated wholly and unilaterally, interact as they do when electroplated?

By answering one question, Harry Kilman has raised many others.

The Hilsch Tube

PHILIP FEARNSIDE

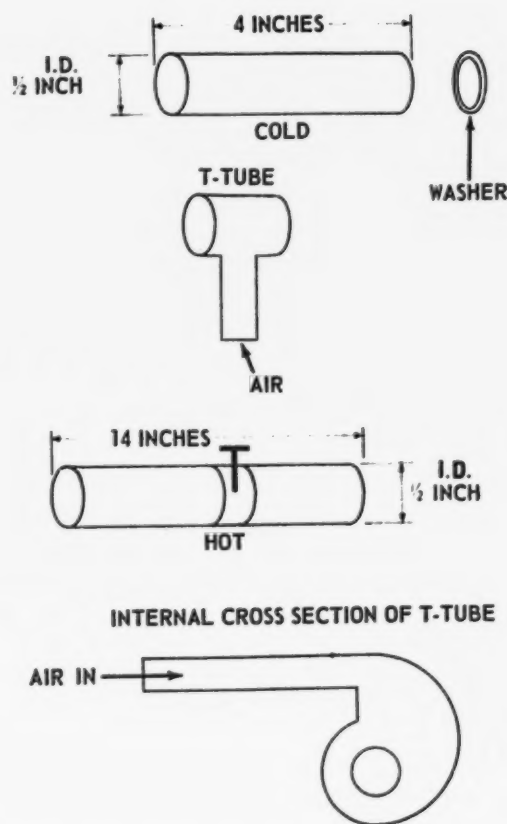
Twelfth Grade, Wellesley Senior High School, Wellesley Hills, Massachusetts. Teacher, Alfonso J. D'Aniello. Winner, Silver Plaque Award, Region I.

This investigation was focused on a laboratory curiosity, the origin of which is not known with certainty. One version credits its invention to an anonymous Frenchman during World War II. Subsequent capture of the device by the Germans placed it in the hands of Rudolph Hilsch who experimented with it and by whose name it is known.

The origin of the device is no more mysterious than is its operation. In appearance, the Hilsch tube is a T-tube. Compressed air is directed into the leg of the T. One arm of the T emits hot air while cold air comes from the other! The device contains no moving parts.

Obviously the tube is not an ordinary T-tube. At the junction of the arms and leg of the T, the stream of compressed air goes through a spiral chamber (see the figure), and the air to the "hot" pipe flows from the periphery of the spiral while air to the "cold" pipe flows from the center of the spiral.

The Hilsch tube built in this investigation produced a temperature difference of 10°F between the "hot" and "cold" pipes (Hilsch reportedly produced differences in excess of 150°F). This investigator built three models of differing dimensions and attempted to get quantitative data on air velocities in different parts of the sys-



tem but came to no conclusions that would contribute to a general theory of operation. He did report that the optimum lengths of the "hot" and "cold" pipes were 17 inches and 6 inches, respectively. Since the lengths of these outlet pipes control their resistance to fluid flow, they may control the "portioning" of the flow from the spiral into the outlet tubes.

The investigator cited "The Amateur Scientist" in *Scientific American* for July 1947 and November 1958 as useful (and only available) references appropriate for the study. Each of these provides detailed plans for a Hilsch tube.

Since there is no completely satisfactory theory for the operation of the Hilsch tube, any systematic, quantitative, and reliable data on its operation and the variables involved may contribute to understanding and/or practical application of it.

The temperature difference between the "hot" and "cold" tubes could be studied as a function of input pressure.

An essentially incompressible fluid, such as water, might be used in place of air.

It would be interesting to know whether the air emitted from the "hot" and "cold" tubes varies in its relative proportions of oxygen, nitrogen, and other components. In other words, can molecules be separated according to mass?

Forces and Acceleration of an Air Bubble

CLIFFORD F. STRITCH, JR.

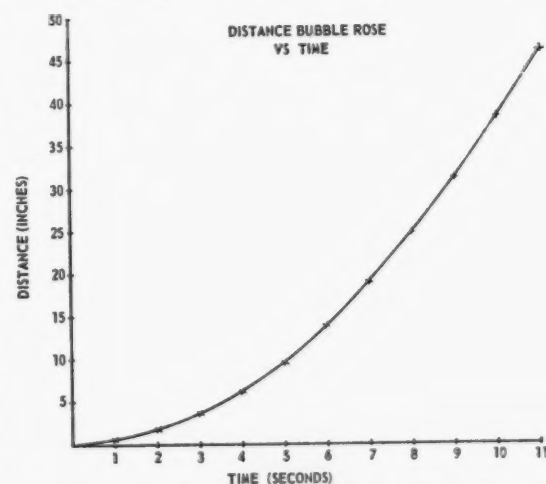
Twelfth Grade, Hawthorne High School, Hawthorne, New Jersey, Teacher, Edward Turco.

Winner, Silver Plaque Award, Region IV

The rising of bubbles of air in a liquid is a common phenomenon. Like many common phenomena, this one is not likely to impress the casual observer. However, to science-sensitized individuals such as Clifford, questions fairly leaped from the observation: "How do the bubbles rise?" "Do large bubbles really rise faster than small ones and, if so, why?"

The principal question chosen from the many possible ones was "If an air bubble is released from the bottom of a column of oil, will the bubble be accelerated?" As stated, the question seems to call for a simple yes or no answer. However, Clifford eventually accomplished two more sophisticated tasks. First, he obtained data that provided an accurate description of the motion of a rising bubble. Second, he analyzed the forces on the bubble that resulted in the observed motion.

Clifford used both 16mm and 35mm cameras to record the upward trip of a bubble in oil. In an attempt to refine his measurements, he used a series of photocells mounted on the side of the experimental tube. The passage of a bubble between a light source and a cell triggered a recording device that produced a record of the time elapsed between successive cells. All methods produced essentially the same data, one set of which is graphed in the accompanying figure.



The graph of distance vs time shows that the upward speed (slope of graph) of the bubble is not constant but is accelerated. A speed vs time graph

could have been constructed from the same data to determine whether the acceleration is or is not uniform (PSSC Physics, Chapter 5).

In analyzing the forces on an air bubble, Clifford identified the following: (1) an upward buoyant force equal to the weight of the displaced liquid, (2) a downward drag force expressed by Stokes' Law— $F_{\text{drag}} = 6\pi r k v$ (F = force; r = radius of bubble; k = viscosity of liquid; v = velocity of bubble at moment considered). The net force on the bubble is then the difference between (1) and (2), though extreme care must be exercised to insure that both forces are expressed in the same units.

It should be noted that neither drag nor buoyancy is constant as a given bubble rises and its volume and speed increase. All data were obtained by using light oil (specific gravity = 0.965) in a glass tube that was 46 inches long and approximately 3 inches in diameter.

The study led Clifford to conclude "... that the acceleration of the bubble is a function of the buoyant force minus the drag force, making the bubbles nonuniformly accelerated."

The experimenter used many good techniques in conducting this study. The study probably could have been improved and a more clearly stated conclusion produced had the investigator given more attention to phrasing the initial statement of problem. This is a common fault among young scientists and is one that the teacher, if aware of it, can anticipate and aid the student to overcome.

At any rate, the investigator in this study should be commended for recognizing a provocative phenomenon in an everyday occurrence.

The following questions could provide the bases for other studies:

1. Are rising bubbles really spherical? (Can Stokes' Law be applied if they are not?)
2. Temperature and solutes (e.g., salts or detergent) affect viscosity. How would variation of these factors affect the rise rate of bubbles?
3. Can the action of helium-filled soap bubbles in air, or bubbles of oil in water, or bits of cork in water be described by a similar analysis of forces?

The Relationships between the Thermal Conductivity of a Metal and Its Temperature, Density, and Electrical Conductivity

DON DUSTIN

Twelfth Grade, Nicolet High School, Milwaukee, Wisconsin. Teacher, Jerome Fischer.

Winner, American Society for Metals \$100 Award and Silver Plaque Award, Region IX

This project consisted of carrying out three major tasks. First, Don acquired knowledge of a theory of heat conductivity and its mathematical expressions. Second, he constructed an apparatus with which he determined the thermal conductivity constants of steel, aluminum, copper, and brass. Third, after acquiring the wherewithal for understanding and gathering data, he attempted to discover relationships between thermal conductivity and other physical properties.

A generally inverse relationship between thermal conductivity and temperature was detected. No relationship was seen when density and thermal conductivity were compared. In plotting his values for thermal conductivity against electrical conductivity values (obtained from tables of physical properties), a logarithmic curve resulted. From this curve Don obtained a formula that expressed the relationship between the electrical and heat conductivities.

A common question students ask concerns the possibility of relationships between two phenomena. For example, one inquires whether, in metals, measures of elasticity and the velocity of sound are related; whether the wearing of eyeglasses and high grade-point averages go together; whether the surface area of a leaf is related in any way to the height of leaves from the ground; or whether a relationship exists between refraction and hardness among crystals. Deciding whether two things or events have a tendency to go together can involve students in statistical measures of correlation.

Relationships can be sought at several levels of sophistication. Scattergrams provide a visual or descriptive clue of relatedness; Spearman's "rank difference" and Pearson's "product moment" statistical methods yield coefficients of correlation. Often, when a relationship is found between two measures, the formula for predicting one

measure from the other emerges, as was demonstrated by Don Dustin.

An Investigation of the Effects of Organo-silicone Derivatives on Alkyl Aromatic Sulfonates

JAMES FRANK

Twelfth Grade, Nicolet High School, Milwaukee, Wisconsin. Teacher, Jerome H. Fischer.

Winner, FSA National Scholarship of \$300

The purpose of this investigation was to discover a compound which would efficiently break down the synthetic detergent molecule in aqueous solution without contaminating the liquid to be separated from the synthetic detergent. The need for such a compound is apparent in the light of present difficulties encountered in effectively removing detergents from sewage.

In the course of his study, the investigator synthesized an "aluminum organo-silicone complex" which apparently fulfills the original purpose and which has other properties of sufficient merit to warrant a patent application.

During the investigation several "limited conclusions" were made which are worthy of further testing. These are:

1. The minimum concentration of detergent needed to produce foaming is independent of temperature but decreases as the "chain length" of the detergent molecule increases.
2. Pure liquids do not foam.
3. Mixtures of liquids (both aqueous and non-aqueous) can be made to foam.
4. Surface-active agents with "high surface viscosity" produce foams which are highly stable (i.e., they last a long time).

EPR Spectroscopy at Microwave Frequencies

KARL MILLER

Twelfth Grade, Woodward School for Boys, Washington, D. C. Teacher, N. Phillips.

Winner, FSA National Scholarship Award of \$300

This study involved the design, construction, and use of various microwave electron paramagnetic resonance spectrometers. Experiments were con-

ducted on 20 crystalline substances, both organic and inorganic. Some theoretical conclusions were reached about the relative importance of "spin-lattice relaxations" and "spin-spin interactions" in broadening the resonance spectrum.

This is the kind of study that requires considerable resources of time,

space, knowledge, and money. In many respects it is typical of the work done by dedicated electronics enthusiasts or students who have reached a high level of sophistication in science in that the results are highly specialized.

This study has considerably more value than has the mere construction of a piece of apparatus since the data

and their implications are the source of interest rather than the "hardware" involved.

Part of the cost of this project was subsidized by the Washington Academy of Science. It sets an example for similar groups across the nation and suggests a source of support for other ambitious student research projects.

EARTH-SPACE SCIENCE

Relationship of Atmospheric Pressure to Precipitation

LAWRENCE SPRENGELER

Seventh Grade, Bear Creek Junior High School, Morrison, Colorado. Teacher, Mr. Ohaver.

Winner, Silver Plaque Award, Region XI

Lawrence observed that the weather in Littleton, Colorado, was subject to sudden changes during the winter. He became cogently aware of variations in wind speed, temperature, sky cover, and precipitation. From his reading he discovered that meteorology is a complex science but that a fundamental relationship exists between atmospheric pressure and precipitation.

For a science project he decided to confirm the generalization that change in atmospheric pressure is accompanied by changes in other components of weather. An aneroid barometer was constructed of simple materials. With this instrument he was able to tell whether air pressure increased or decreased between two readings. Along with daily barometric readings, Lawrence qualitatively noticed and recorded wind speed, temperature, sky cover, and precipitation. After 21 days of observations, Lawrence reported a definite relationship between pressure change and the precipitation of snow. He was unable to detect a relationship between pressure and the weather components: wind speed, temperature, and sky cover.

An obvious next step would be the introduction of the concept of quantification as applied to the gathering of data. The barometer should be calibrated. Temperature, wind speed, and cloud cover should be measured. Claimed relationships between weather components should become mathematically defensible.

Several excellent books have been written to guide students through the puberty of quantification. Two of these books are:

1. W. J. Youden. *Experimentation and*

Measurement. (An NSTA VISTAS OF SCIENCE book) Scholastic Book Service. Scholastic Magazines, Inc. New York. 1962.

2. Philip Goldstein. *How to Do an Experiment*. Harcourt, Brace & World, Inc. New York. 1957.

La Jolla Beach Sands

ROBERT STRICKLAND

Eighth Grade, Pacific Beach Junior High School, San Diego, California. Teacher, John Gregory.

Winner, Silver Plaque Award, Region XII

This investigation starts with a close-to-home-but-often-overlooked substance—sand. Beach sand was the specific type, but sand of some type is found and commercially exploited in every state. Sand has application in making glass and concrete, is a source of titanium, and is a recreational resource whether on a beach or in a sandbox.

In this case, the geologic aspects of sand were investigated. As a result of analysis by mechanical separation (sieving) and chemical and microscopic tests, the investigator described samples of sand from several Pacific Ocean beaches and the cliffs behind them. He found that, in several cases, the sand on the beach differed radically from the sand in the cliff. This led to the conclusion that some of the sands must have originated elsewhere—possibly from the beaches to the north or another yet unknown source.

Inland locations can provide numerous sand samples from which analysis and deductive thought could reveal something about past geological events. By the geologists' definition, sand is mineral or rock particles that are between $\frac{1}{16}$ mm and 2 mm in diameter. Anything finer is regarded as silt.

Specific studies might be focused on the sands found down the course of a river or creek. One could investigate the plants associated with dry sand deposits or the aquatic life associated with wet sand deposits.

From a technological viewpoint, one could investigate the relative desirabilities of various sands in making molds for casting metals or in producing durable concrete.

A Comparison of Rocks Based on Their Specific Heats

LANI PECK

Eighth Grade, Milwaukie Junior High School, Milwaukie, Oregon. Teacher, Forest Trubey.

Winner, Silver Plaque, Region XI.

This investigator made precise determinations of the specific heats of various rocks in the hope that these values could be used to identify rocks, as hardness is used.

A common calorimeter of the type found in high school laboratories was used with a thermometer that could be read to the nearest 0.2°C . The data obtained were sufficiently accurate to allow calculations of specific heats to three significant figures.

A slight modification was made in the common laboratory procedure for determining specific heats in that the pulverized rock samples were at room temperature (23°C) and the water bath in which each sample was placed was heated to 65°C . This resulted in a measurable cooling of the water as the whole system came to equilibrium. Care was taken to correct for the cooling rate of the calorimeter and water when no sample was used.

Six determinations for the specific heat of limestone averaged $0.212 \text{ cal/gram/}^{\circ}\text{C}$ with all values within 0.007 of the average. Six basalt determinations produced an average of $0.200 \text{ cal/gram/}^{\circ}\text{C}$. Corresponding values based on single determinations were: obsidian $0.195 \text{ cal/g/}^{\circ}\text{C}$, diorite $0.195 \text{ cal/}^{\circ}\text{C}$, rhyolite $0.181 \text{ cal/g/}^{\circ}\text{C}$, quartzite $0.181 \text{ cal/g/}^{\circ}\text{C}$, pegmatite

0.206 cal/g/°C, and granite 0.187 cal/g/°C.

The investigator concluded that while actual differences in specific heats are not sufficient to identify each rock, there is a great difference between the sialic (aluminum-rich silicates) and the simatic (magnesium- and iron-rich silicates) rocks, the latter having higher specific heats.

The investigator reported that no detectable difference in specific heat was observed among three limestone samples even though they were obtained from "... three different areas about 100 miles apart." A replication of this study could use limestone samples from sources much farther apart as a check on the conclusion that all limestone has the same specific heat. Also, rigorous mathematical analysis could be used to judge whether slight variations from the average are significant or not.

Some investigators could refine the method of determining specific heat by using a thermometer calibrated in 0.1°C divisions or by other modifications that might add another significant figure to the results.

It should be noted that this experimenter's results are probably rather accurate since the fourth edition of *Mechanical Engineers' Handbook* gives a value of 0.217 cal/g/°C as the specific heat of limestone. It should be further noted that this investigator did not have this specialized reference available and his work undoubtedly represents an independent discovery and, as such, is outstanding.

In addition to the refined replications of this investigation that have been suggested, consider the following questions as promising extensions:

1. Can specific heat be used to distinguish fossils of the same genus but from different geologic ages? For instance, are the specific heats of Devonian and Ordovician brachiopods significantly different?
2. Do sands from different sources differ significantly in specific heat?
3. Is there a correlation between specific heat and hardness of rocks or some other physical property?

Tornado Chamber

STEVEN RAMSDELL

Ninth Grade, Julia E. Test High School, Richmond, Indiana. Teacher, Mrs. Crabb.

Winner, Silver Plaque Award, Region VIII

A television program inspired Steven to study the meteorological conditions that accompany tornadoes and the ideas about the mechanics of tornadoes. He learned that the thermodynamically unstable weather out of which tornadoes are born includes a layer of warm moist air sharply overlain by thick, cold, dry air. Strong winds that occur in the upper atmosphere and fall forward and the convective lifting of the warm air somehow combine to form the trigger that sets off these violent storms.

Steven believed he could produce tornado conditions in a controllable closed system. He constructed a frame 24 x 42 x 42 inches and covered it with transparent plastic sheeting. Air was warmed with electric heating coils on the base in the lower left, while air was cooled by dry ice in a rack suspended in the upper right of the chamber. Winds from two vacuum cleaners blew over the rack and the heater. "Tornadoes" that Steven created were made visible with confetti that was sprinkled on the floor of the chamber. Steven created whirlwinds five to seven inches in diameter with life spans of from three to five seconds.

The research use of the tornado chamber has just begun for Steven. Consider some of the questions he can ask about the phenomena that occur within the chamber. What general patterns of air movement can be observed in the chamber as each of the conditions is varied? What are the rotational and vertical wind speeds of the simulated tornadoes? Do the whirlwinds result from localized violent convections followed by a rushing in of air, or are the whirlwinds mechanically generated by the interaction of winds that have various speeds and directions? What air pressures exist within and near the storms?

One can study the weather conditions of real tornadoes relatively easily. Tornadoes frequently occur in the United States during late spring and early summer. The Daily Weather Map produced by the United States Weather Bureau provides in daily sequence considerable raw data for the interested

student. Many organizations that subscribe to the Map maintain files of previous maps.

Is the Climate of Illinois Changing?

MARY ANN KEENEY

Tenth Grade, Regina Dominican High School, Wilmette, Illinois. Teacher, Sister Roberta Marie, O.P.

Winner, Silver Plaque Award, Region VIII

This study is different from most projects in that it makes use of data readily available from the United States Weather Bureau rather than that obtained by the investigator. Most Weather Bureau stations have records dating back to the turn of the century at least and, therefore, could provide the basis for similar studies in other regions, or for studies in which different regions are compared.

In this project, the average high and low temperatures for the months of October through January formed the criteria for making generalizations about changes in the climate. For the seven Illinois stations checked, a warming trend was found. However, for several stations, extremes were greater for both low and high temperatures in recent years.

Since climate implies factors in addition to temperature, a more comprehensive study would take into account precipitation, humidity, cloudiness, and wind direction. A comprehensive study of climatic changes would make a good team investigation, with each member of the team specializing in one factor.

Recent evidence suggests that the Arctic Ocean may soon (15 years) be open water for a significant part of the year. Should this become a reality, northerly winds will contain more moisture than they now do, and, therefore, the annual snowfall in North America should increase. If the snowfall is great enough, there is the possibility that it will not melt completely in the summer in high latitudes, thus leading to an annual accumulation and the advent of another ice age. This situation will inevitably lead to increased interest in climatology and possibly more noticeable changes than have been apparent in recent years.

One can proceed to evaluate these theories through investigations that seek answers to the following questions:

1. How do condensation nuclei affect the size of droplets in a cloud?
2. What is the effect of temperature stratification on air pollution?
3. What causes the sky to vary in blueness?
4. How does the electrical potential gradient of the atmosphere vary with changes in the weather? Could this factor be used in making weather predictions?

Stellar Spectrum

HARRY M. DOBBINS

Twelfth Grade, Heelan High School,
Sioux City, Iowa. Teacher, Sister M.
Columban, O.S.F.

Winner, Silver Plaque Award, Region
IX

The purpose of this project was to describe the motions of a star by an analysis of its spectrum. To observe stellar spectra directly, Harry constructed a 6-inch reflecting telescope

having a 30-inch focal length. He ground the mirror to a reported accuracy of within 0.05 of one wavelength of sodium light. He also built his own grating spectroscope. The width of the slit of the spectroscope was one micron. The achromatic lens of the collimator and telescope had 3-inch focal lengths. A reticle, placed in the eyepiece system, enabled visual measurements.

Harry chose to study the star Sirius. He noted that the spectral hydrogen line of 4,101.8 Å had shifted toward the red to an apparent wavelength of 4,102 Å. To these data he applied the Doppler formula calculating the radial velocity of the star. His calculation indicated that Sirius was receding from the earth at the rate of 9 miles per second. Again using the Doppler principle and properties of the Sirius spectrum, he calculated a rotational speed. He further detected the spectrum of the companion star, Sirius B, observations of which revealed a red shift. He concluded that Sirius B was revolving toward the back side of Sirius.

Expense and time pressures may prohibit an interested person from studying directly the physical properties of stars. However, the resourceful student should be able to obtain spectrograms of stars which he can compare to spectra from stationary light sources.

Other lines of investigation may include:

The concept of radial velocity is involved in several puzzling earthly phenomena. How, for example, can an observer at a football game determine radial velocity (rate of gain or loss) of a ball carrier when the observer is seated behind the goal line?

An analogous Doppler effect occurs with sound. Are there instruments and procedures for determining the relative velocities of sound-emitting moving objects?

Additional information about the physical characteristics of a star can be revealed through analysis of its spectrum. What, for example, can be learned about the sun through a study of its spectrum?

MISCELLANEOUS

Mystery in the Mains

ROBIN RAY

Eighth Grade, University Junior High School, Bloomington, Indiana. Teacher, Charles Souers. Winner, Silver Plaque Award, Region VIII

"Cities throughout the United States have reported build-ups of iron and manganese deposits in the distribution pipes of their water service systems. [Many] Indiana cities . . . have reported deposits to the extent that complete clogging sometimes occurs. These iron and manganese deposits have occurred even when tests showed the water involved to be relatively free of iron and manganese ions."

The preceding paragraph describes the general problem area which was investigated. Experimental evidence was obtained that was intended to answer the specific questions:

- a. "Are there bacteria which thrive on manganese and iron and which get into the water distribution system of cities?"
- b. If there are such bacteria, "Does the season or the source of the water supply affect [their] prevalence?"

On the basis of the tests conducted, water from two of seven Indiana cities was found to have "strong possibilities" of containing "iron and manganese thriving bacteria" in samples taken "during the late summer." But no evidence of such possibilities was found for any samples taken during the winter. The investigator did not report whether or not the two cities had experienced problems of iron and manganese build-up. Both of these cities obtain their water from the Ohio River, a fact that distinguishes them from the other five cities.

The basic experimental technique was to inoculate two cultures containing 10 ml of "sterile tryptone glucose extract agar" with 1 ml of water sample and to incubate for 48 hours. "A small amount of manganese" was added to one culture, and "a small

amount of iron" was added to the other. Subsequently, a colony from each culture was transferred to test tubes containing "nutrient broth" to which had been added: a—"a small amount of manganese," b—"a small amount of iron," or c—nothing.

The culturing procedure was followed by microscopic and staining (gram) characterizations.

Other investigators may well pursue the same basic problem, particularly in other communities where manganese-iron deposit has been noticed. Several suggestions can be made for such studies:

1. Do the manganese nodules found on some ocean floors offer a clue to solving the mystery?
2. Does the literature contain any clues?
3. Would highly quantitative techniques produce more conclusive results (e.g., controlling 'exact concentrations of manganese and iron ions)?
4. Would a large (if possible, more concentrated) water sample provide more conclusive data?
5. In all the foregoing comments, there is an implicit assumption that bacterial action is the mechanism of deposition. What other mechanisms are possible? Is electrolytic deposition (replacement) a possible answer? Is the source of manganese and iron really the water flowing through the pipes?

Bamboo as a Reinforcement for Concrete

DEBORAH COURSEY

Eighth Grade, Miami Springs Junior High School, Miami Springs, Florida. Teacher, T. F. Ryan. Winner, Silver Plaque Award, Region VI

The first concrete was made more than two thousand years ago. Today, concrete is being used in an increasing number of interesting technical applications. Floating bridges and poured concrete homes are but two examples.

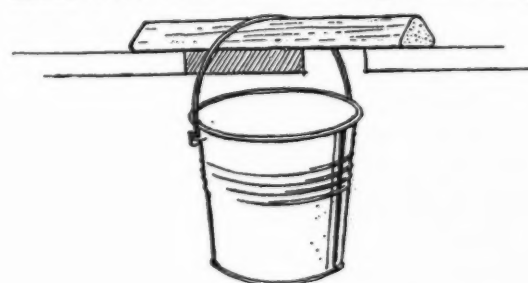
Many modern applications depend on the concrete's being reinforced to increase its tensile strength. Reinforced concrete was invented in the mid-1800's.

The investigation reported here attempted to evaluate bamboo as a reinforcement for poured concrete. In most structural applications, steel is used as reinforcement, but a cheaper substitute would be desirable.

The investigator measured the tensile and compressional strengths of cured and uncured bamboo and its "modulus of elasticity." Further tests measured the strengths of bamboo-reinforced concrete test bars. The overall findings . . . "indicate that by using properly seasoned bamboo, desirable results are obtained."

In a study like this, test apparatus is a problem. Though this investigator was able to borrow industrial testing apparatus, a simple homemade device as shown in the accompanying sketch would suffice.

The test bar (which can be cast in a foot-long piece of angle iron) is supported at both ends and is loaded by a bucket attached to the middle. Weights are added to the bucket until the test bar breaks. The general problem of reinforcing concrete at minimum cost could be investigated along



many lines. Consider the following questions as starting points:

1. Can concrete be reinforced by dried corn stalks? by manila rope? by any other materials?
2. Can reinforcing materials such as steel, bamboo, or others be made more effective by using a bonding agent to make the concrete adhere more securely to the reinforcing material?

Strength of Glued Joints

KEMPER C. STONE

Eighth Grade, Portola Junior High School, El Cerrito, California.

Teacher, P. Perry.

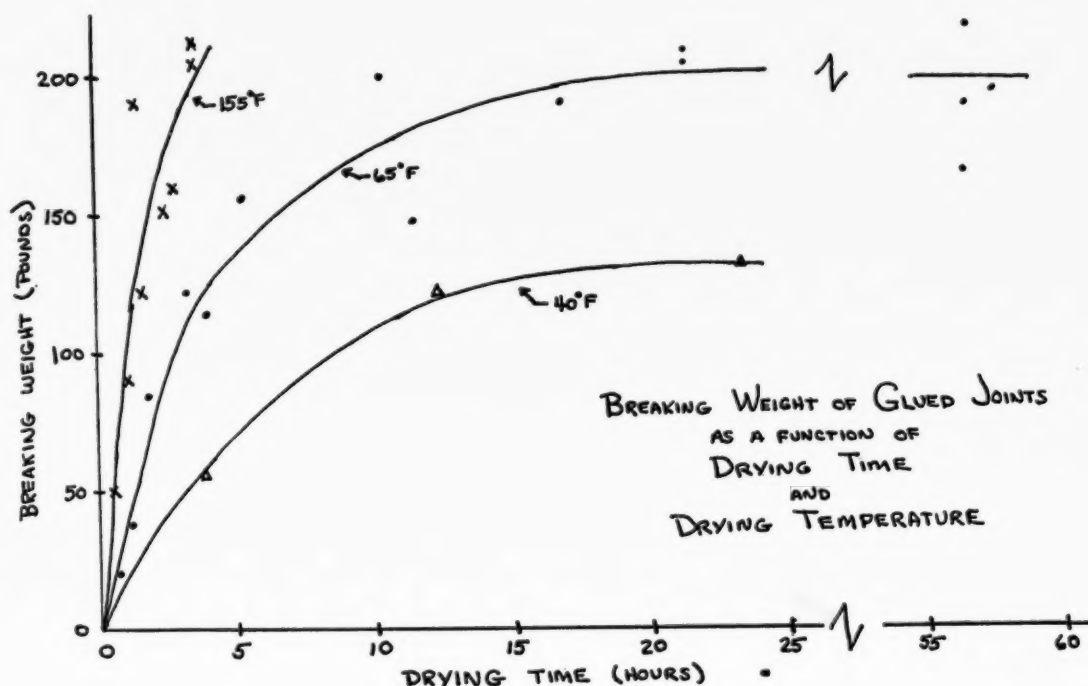
Winner, FSA Regional Award of \$25 Savings Bond, Region XII

In this study, the effects of drying time, temperature, and other factors affecting the strength of a glued joint were investigated. In all cases one kind of glue (Elmer's Glue-All) was used to join wooden test blocks that were $\frac{3}{16}$ square inches in area on the ends that were joined. End-to-end (butt) joints were always used.

The investigator constructed a testing device in which the glued blocks were suspended one above the other. Sand added to a bucket provided the force to pull apart the glued joint. Two hundred pounds was the practical limit that the device could produce, and, in some cases, this was not sufficient to break the joint.

More than 40 trials were conducted and many contributed to some clear-cut results that were summarized neatly by the experimenter in the following graph.

As part of the overall study, it was found through microscopic examination that breaking occurred through



"failure of the glue." However, it was not made clear whether separation occurred between glue particles or between wood and glue particles. It was reported that 50X magnification showed air spaces between wood and glue.

Further studies suggested by the experimenter and his investigation are:

1. Could detergent be added to the glue to promote "soaking-in" and strengthening the joint?
2. What special preparation (physical or chemical) of the surfaces to be

joined could enhance the strength of the joint?

3. Would similar results occur if metal or plastic were joined instead of wood?
4. Does a mixture of two types of glue produce a stronger joint than does one type of glue alone?

While the above questions would lend themselves to serious experimental study, the more basic question "Why does glue stick?" could be the basis for a long-range project.

A Comparison of the Self Concept of Ninth-Graders in Junior High with That of Tenth-Graders in High School

NETTA HOLLEY

Ninth Grade, Northwestern Junior High School, Natchitoches, Louisiana. Teacher, Mrs. M. J. Cousins.

Winner, \$50 Savings Bond Award, Region X.

Do ninth-graders, because they are the senior members of a school group, have a higher opinion of themselves than do tenth-graders?

Do tenth-graders, because they are the lowest members of a school group, have a lower opinion of themselves than do the ninth-graders?

How do the self concepts of boys compare with the self concepts of girls within ninth- and tenth-grade groups? for the whole population? If there are differences, what are the significances of these differences?

To obtain data in answer to the above questions, Netta administered *The Self Concept Scale*. This paper and pencil instrument asks subjects to rate themselves twice with respect to 30 adjectives, such as "polite," "popular," and "mean." The first rating describes "the way I am." The second rating describes "the way I'd like to be." The discrepancy between the two ratings is the raw score for the individual. The higher the score the less satisfied the person is with himself.

Data were statistically treated. The Median Test was used to test null hypotheses at the 5 percent level of significance. Netta found: (a) tenth-graders held higher self concepts than did ninth-graders, (b) at the tenth grade, girls held higher self concepts than boys, (c) at the ninth grade the self concepts of boys and girls were not different, and (d) for the total population the self concepts of boys and girls were not different.

What are the next questions for the social scientist in pursuit of knowledge about self concepts? Anyone can answer questions—or at least try to answer someone else's question. A major creative act in inquiry is asking your own questions.

A Study of Three New Jersey Indian Sites

EDWIN STRUVE

Tenth Grade, Chatham High School, Chatham, New Jersey. Teacher, Charles Appler.

Winner, Silver Plaque Award, Region IV

Edwin is an archaeologist. His choice of reading, his associations, his membership in a learned society, and especially his dedication to field and laboratory research attest to this fact.

Edwin's special archaeological interest is the Indians that lived in the area that is now New Jersey. The award-winning paper reports the author's findings from excavating and collecting at three prehistoric sites. For this project he collected over 1,000 artifacts including arrowpoints, drills, scrapers, pottery fragments, bannerstones and spears. From such clues as workmanship, composition, and position in the soil, Edwin was able to suggest a new picture for each of these Indian settlements. The presence at one site of a great diversity of tools suggested permanence, while at another site relatively small quantities of flakes indicated little stone work suggesting that the area may have been a campsite of limited occupation. At another site Edwin found bannerstones which indicated occupation during the Archaic Period. Among his findings at this site was a hoe. Since agriculture was not known to have been practiced during the Archaic Period, the presence of the hoe suggested occupation during the succeeding Woodland Period when farming was practiced. To be sure, Edwin has amassed considerable evidence to substantiate these and other conclusions.

The process of creating an image of a thing or an event using fragmentary evidence is the focus of much scientific research. Sample problems in deduction from various areas of science follow.

1. *Physics.* What can be inferred about the velocities of automobiles before collision on the basis of an examination of the wreckage?
2. *Psychology.* What can a photograph tell you about an individual?
3. *Geology.* What could a sample of surface matter from the moon tell you about its history?
4. *Biology.* What information about a lake can be inferred from a sample of sediments taken from the bottom of the lake?
5. *Medicine.* What information about an individual can be concluded from an analysis of his blood?
6. *Chemistry.* What is revealed about a nation's technology, trade, values, or other history by metallurgical analysis of its coins, past or present?

A Study of the Tensile Strength of Kraft Paper Before and After the Addition of Sizing Agents

ROBERT DERING

Tenth Grade, Brother Rice High School, Chicago, Illinois. Teacher, Brother J. M. Knowles, F.S.C.H.
Winner, FSA Regional Award of \$50 Savings Bond, Region VIII

Nearly 40 million tons of paper and paper products will be produced in the United States this year. This amounts to 400 pounds for every person in the nation. The variety of paper products is amazing—newspaper, wrapping paper, cardboard, and paper cups are common. Paper clothing (including swimsuits!) may become more common in the next few years.

A single sheet of writing paper is fairly easy to tear, but if you try pulling it apart, its strength will surprise you. This resistance to being pulled apart is "tensile strength" and may be measured in pounds. Needless to say, the thickness of the paper sheet affects its tensile strength. Because many uses for paper require tensile strength, there has been continued interest in attempting to increase this property. This study investigated one approach to increasing paper's tensile strength—that of adding surface coatings.

Cornstarch and sodium alginate, in water solution or suspension, were the substances used as surface coatings. Tensile strength was measured by using a homemade instrument. Throughout the study, a single grade of Kraft paper was used. (A common use for Kraft paper is in making grocery bags.)

The investigator found that "the tensile strength of the paper increases in a linear proportion to the amount of sizing agent added." It seems that this increase in strength must have a limit and could be the basis for further investigation, as could experiments built around hypotheses of possible reasons for the increased strength.

Other related problems worthy of investigation are:

1. What, if any, treatment could produce high tensile strength in wet paper? (Remember the paper swimsuits!)
2. Can the tensile strength of paper be increased by adding a substance to the paper slurry before it is formed into sheets? (Check a reference on paper-making.)

3. Although cellulose fiber from trees is most commonly used in making paper, could other sources such as straw, cornstalks, and grass be used?

Can Emotionality Resulting from Maternal Factors Be Modified by Clinical Therapy?

MARILYN BEECH

Eleventh Grade, Fulton High School, Atlanta, Georgia. Teacher, Robert Rivers.

Winner, Silver Plaque Award, Region VI.

In 1963 Marilyn began studying the effects of abnormal mother-infant relationships on the growth and behavior of offspring in maturity. She discovered that when mother rats were periodically shocked, their apparent anxieties were transferred to infants which as adults were more emotionally disturbed and lighter in weight than the normally mothered controls. Similarly rat litters that were nursed on alternate days by two different mothers (parental inconsistency) were also adversely affected in maturity.

This past year Marilyn endeavored to discover how and when best to treat disturbed rat pups. Her objective was to reduce the emotional upset anticipated in the offspring of mothers given electrical shock (anxiety mothering) and offspring of mothers rotated between two litters on alternate days (parental inconsistency). Her therapy was clinical. Rats were maintained in "free environment boxes," a complex environment enabling social interaction. Control rats spent the period from weaning to maturity in cages. To determine the optimum stage in growth for the application of therapy, rats were placed in free environment boxes either during the prepubertal period (day 25 to day 50) or the postpubertal period (day 61 to day 86). She concluded that only prepubertal therapy was effective in treating the emotionality (measured as a defecation rate) and weight reduction in mature rats that were affected during infancy by the mother factor.

Much of the research in experimental psychology on laboratory animals such as rats, pigeons, and monkeys endeavors to discover clues about how humans behave in analogous situations. Marilyn states that she plans to continue her work by investigating other forms of therapy. What might be some effective

tive ways of treating animals whose infancy was warped either by an anxious mother or by having gone from one mother to another?

Evolution of Porphyrins in Fossils

STEPHEN WEISSMAN

Twelfth Grade, Central High School, Philadelphia, Pennsylvania. Teacher, Fred M. Hofkin.

Winner, Silver Plaque, Region IV.

Porphyrins are an interesting group of organic compounds that are closely associated with many living organisms. "Porphyrins are present in all pearl-forming shells but their presence in other shells [follows] no set pattern."

This investigator has analyzed a variety of fossil shells for the presence of porphyrins in the hope of finding evidence to "establish a relation between the presently accepted biosynthetic pathways and the paleobiological and paleogeological sequences."

This rather ambitious undertaking has not been completed to date but in the process of obtaining data, the investigator has found evidence for the existence of a "new porphyrin" that has heretofore been unrecognized.

The evidence for "porphyrin-X" is in the near ultraviolet absorption curve for a pyridine solution extracted from the fossil material. The transmission curve in this region (0.400-.435 microns) has a double peak instead of the single peak associated with the usual porphyrins.

To date the investigator has isolated porphyrin- ζ only from *Pterochaenia fragilis*, a Devonian pelecypod, or from the Genesco black shale in which the fossil was embedded.

Replication of this investigation is needed to confirm the existence, of porphyrin-X. To do this will require the use of a Beckman DK-1 Recording Spectrophotometer or its equivalent. Industrial or college laboratories might allow their instruments to be used by qualified high school students. The procedures for extracting porphyrins from fossils or shale can be carried out in the high school laboratory. The basic extraction procedure involves: (1) "dissolve shell in minimal amount of 6N HCl," (2) filter, (3) wash residue with 10 ml pyridine. Both the acid and the pyridine solutions should be analyzed for the presence of porphyrins. Needless to say, improved procedures are always possible, and the thorough investigator will not overlook these possibilities.

In addition to replication, variations suggested by the following questions could be introduced:

1. Could the fact that porphyrins in acid solution exhibit two absorption bands in the visible region be used to identify porphyrin-X?
2. Can porphyrins (especially porphyrin-X) be found in Ordovician (older than Devonian) pelecypods or shale or both?

Ultrasonic Detection and Ranging Applied to an Auto-Fog Safety Detection System

JAMES PHIFFER

Twelfth Grade, Don Bosco Technical High School, South San Gabriel, California. Teacher, Reverend Thomas Prendiville, S.D.B.

Winner, FSA National Scholarship of \$300

This study illustrates the close relationship between engineering (technology) and science. The problem was to construct a device to warn a driver when an obstacle is approached in fog. Before the device could be invented, preliminary considerations had to be made involving sound and electromagnetic radiation—their velocities, absorption by air, and resolving power.

The device as finally built is a kind of sonar unit. It is unique in that most sonar systems are designed to operate underwater rather than in air as this one does. A notable exception is the natural "sonar" of bats.

The project required considerable experimentation in electronics circuit design and construction. The basic features of the device are: (1) an ultrasonics (18 kc) transmitter, (2) receiver, and (3) analyzer of reflected pulses which controls a signal to the driver. It is claimed that the unit has an effective range of six meters and can detect an object as small as 0.2 square meters in cross section.

Possible extensions of this study could be:

1. Other applications for sonar in air
2. Other systems to solve the basic problem of preventing auto wrecks in fog (or at any other time!)
3. Basic research on the resolving power of sonar systems

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